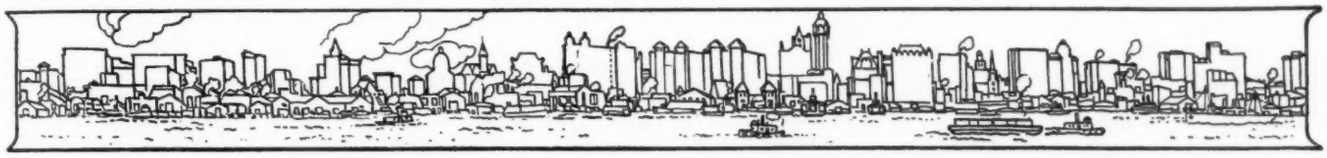
Power. and THE ENGINEER

EVERYTHING ABOUT THE GENERATION AND TRANSMISSION OF POWER



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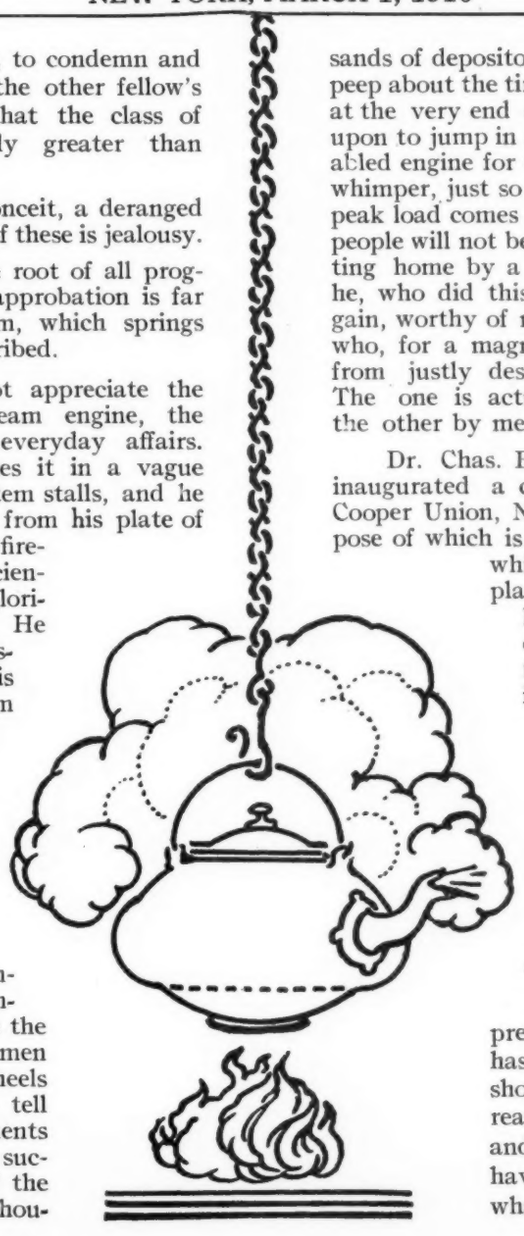
IT IS easy enough to criticize, to condemn and to discount the merits of the other fellow's effort; so easy, in fact, that the class of knockers is overwhelmingly greater than that of the boosters.

Criticism may spring from conceit, a deranged liver or jealousy; and the greatest of these is jealousy.

Healthy dissatisfaction is the root of all progress, but a healthful amount of approbation is far more necessary than all criticism, which springs from origins such as those described.

The general public does not appreciate the part which machinery—the steam engine, the dynamo, the pump—plays in everyday affairs. The homefaring commuter realizes it in a vague way when the electric trolley system stalls, and he is left stranded and hungry far from his plate of steaming soup and comfortable fireside. He blasphemes at the inefficiency of the system rather than glorifies for its remarkable efficiency. He loses sight of the fact that the system he so vehemently condemns is the same one which has carried him home upon countless occasions in spite of unfavorable conditions about which he never even dreams, at the cost of great effort on the part of those men who must toil early and late in order that he may ride at all.



And just as the average man fails to appreciate the important part played by machinery, so also he does not realize the responsibilities placed upon the men whose part it is to make the wheels go round. The newspapers will tell in great detail of the achievements of the eminent lawyer: How he succeeded in securing the acquittal of the bank buster who got away with thousands of depositors' dollars. But they never print a peep about the tired, two-dollar-a-day engineer who, at the very end of his long shift, is perhaps called upon to jump in and work like a Trojan at the disabled engine for two or three hours longer without a whimper, just so the engine can be started when the peak load comes on and several hundred thousand people will not be inconvenienced or delayed in getting home by a partially crippled service. Is not he, who did this without hope of glory or personal gain, worthy of more consideration than the man, who, for a magnificent fee, simply saved a scamp from justly deserved retribution? We think so. The one is actuated by a simple sense of duty, the other by mere cupidity.

Dr. Chas. E. Lucke, of Columbia University, inaugurated a course of free public lectures at Cooper Union, New York, on February 7, the purpose of which is to show the very important part which the science of power generation plays in every affair, the influence it has had in shaping present conditions, the rate at which its influence is growing, and finally the increasing importance of the role played by the engineer and mechanic. In the welfare of the nation their training is fast assuming greater importance than the training of its generals.

Abstracts of these lectures will be printed as fast as they are delivered and we hope that you will glance over the one in this and succeeding issues.

Doctor Lucke knows and appreciates the value of your work. He has given some reasons why others should appreciate it, too. These reasons should be interesting to you and perhaps to others who hitherto have failed to realize and appreciate what you are doing.

Most Powerful Turbines Ever Built

18,000-Horsepower Hydraulic Reaction Turbines of the Vertical-shaft, Single-runner, Inward-flow Francis Type Operate under 525-foot Head at Efficiency of 89 Per Cent.

BY H. BIRCHARD TAYLOR

The four 18,000-horsepower hydraulic turbines recently installed and tested in the power house of the Great Western Power Company, on the Feather river, at Oroville, Cal., represent the highest development in the art of water-wheel design and construction. There are a number of unusual features in connection with their design and construction which are of interest to the engineering profession at large, as well as to those who are more or less intimately connected with hydraulic engineering.

(1) Each turbine has a greater capacity by several thousand horsepower than any existing turbine in any other installation in this country or in Europe. The highest powered wheels at Niagara Falls are the four 13,500 horsepower turbines designed and built by the I. P. Morris Company, of Philadelphia, Penn., for the Toronto Power Company. Therefore, the Great Western units are each about 33 per cent. greater in capacity than any unit in the great installations at Niagara.

(2) The power is developed in a single wheel or runner. Each 13,500-horsepower unit referred to above is a two-runner turbine, consequently the capacity of each runner is only 6750 horsepower.

(3) The hydraulic head for which the turbines have been designed, namely, 525 feet, is considerably higher than the heads to which it has been customary to apply the reaction type of wheel. It has only been within the last few years that the reaction turbine has been applied to heads much over 300 feet, the impulse wheel having been used almost exclusively for heads above this value.

(4) The guide vanes and wheel vanes have been so designed as to practically eliminate the erosion or pitting of the vane surfaces.

(5) The efficiencies of the turbines, which have been determined by careful tests on all four wheels in place, show conclusively that, from a hydraulic point of view, the wheels are classed among the most efficient in the world.

(6) The turbines complete, with the governing apparatus, are the products of American design and manufacture, and are representative of the highest class of work now being turned out by the engineers of this country along the lines of specially designed apparatus, a branch of the art about which the American engineer knew little or nothing 15 years ago.

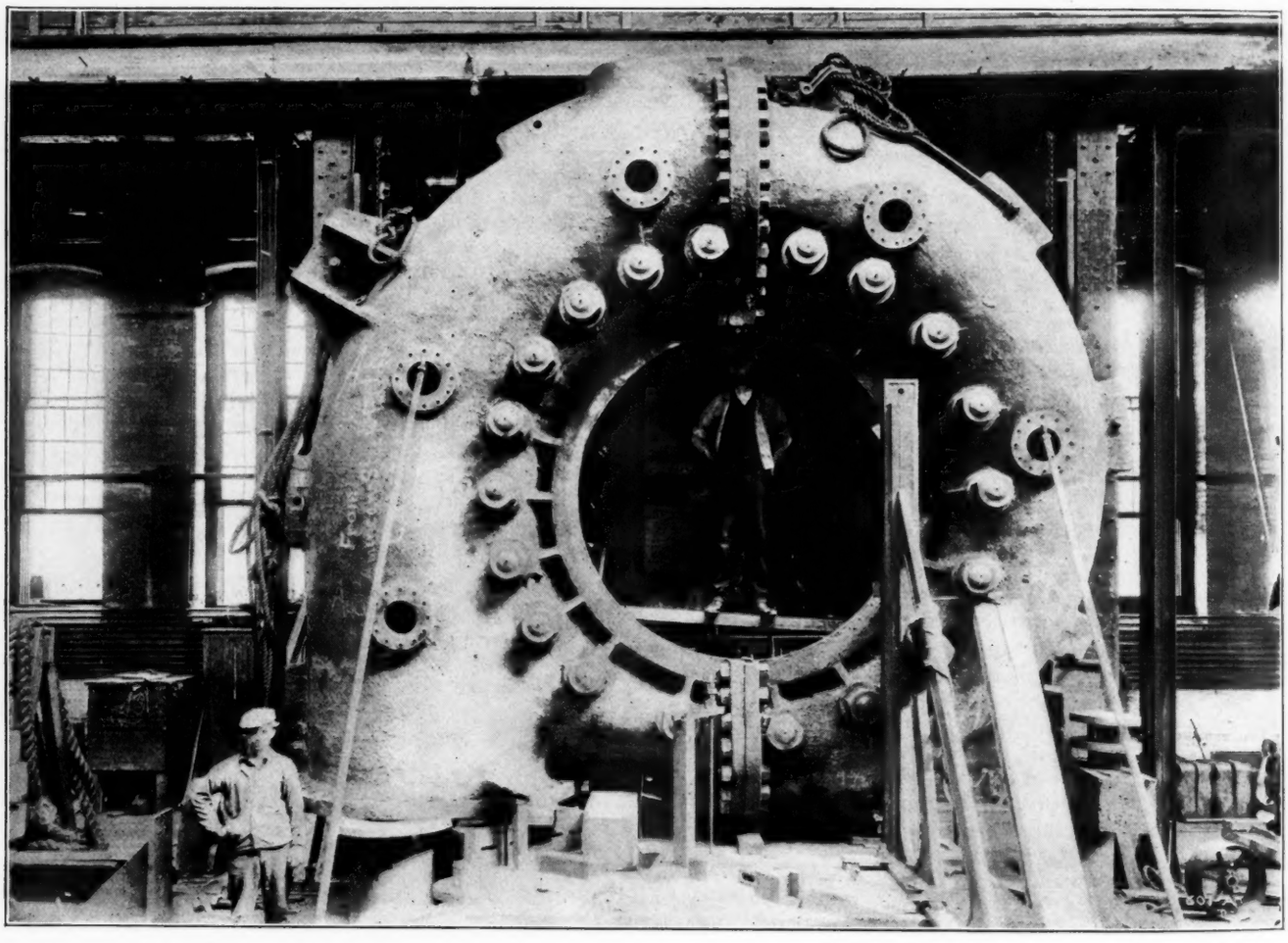


FIG. 1. VOLUTE CASING OF 18,000-HORSEPOWER TURBINE

DESCRIPTION OF TURBINES

The turbines are of the vertical-shaft, single-runner, inward-flow, Francis type, each having a normal capacity to deliver 18,000 mechanical horsepower to the electrical generator which it drives when operating under a head of 525 feet and

when running at a speed of 400 revolutions per minute.

The turbine units complete, with the governing apparatus, were designed and constructed by the I. P. Morris Company, of Philadelphia, Penn.

The general arrangement of one of the turbines is shown in Fig. 2. The reader may gain an idea of the size of the units by referring to Fig. 1, which shows the cast-steel casing set up on one side in the shops of the I. P. Morris Company.

The runner, which is constructed of special bronze, revolves in a cast-steel volute casing. The water is delivered to the runner through cast-steel movable guide vanes, situated at the throat of the casing around the periphery of the runner. For any particular load on the turbine, the governor will adjust the gates to such a position that the openings between the vanes will admit sufficient water to the runner to enable it to develop the power required to balance that load at the normal speed of 400 revolutions per minute.

Each guide vane has cast with it a long shank on its upper side, which extends through a stuffing box and two bearings to the upper side of the upper head cover, and there it is connected through a lever and a link to the cast-steel operating ring which slides in a groove on the circumference of the head plate. A short shank is cast with each vane on its lower side and this extends into a bearing in the lower head cover. Thus the shank or fulcrum pin of each vane is held rigidly in alinement by three bearings.

The operating ring is connected by two piston rods, which are controlled by two operating cylinders connected in parallel and mounted upon the wheel casing. The cylinders are connected through piping to the main valve of the governor. Lost motion in the operating mechanism is reduced to a minimum by having two pistons controlling the gear from opposite sides of the ring.

The piping between the governor and operating cylinders is made of large diameter, so that the inertia of the oil in the piping between the governor and the cylinders may be overcome in a very small increment of time for all movements required by the gates. Thus the whole operating mechanism is made extremely sensitive and the guide vanes will begin to move before the speed of the turbine has varied more than ½ per cent. from normal.

The normal pressure of the water in the wheel casing is about 220 pounds per square inch, corresponding to the total head on the turbine less the draft head. Each casing was subjected to a pressure of 400 pounds per square inch, in the shops of the I. P. Morris Company before delivery, and all parts of the apparatus subject to this pressure have been designed to withstand it, on a basis of keeping the stresses in the various materials considerably below their respective elastic limits.

Fig. 3 shows one of the turbines partially erected in the shops. By referring to it the reader will understand the arrangement of the operating gear just described. It was while in this position that the hydraulic test was made on the wheel casing. Suitable headers were bolted to the openings in the casing to make it water-tight during the test.

The turbine section of the vertical forged-steel shaft, which connects the runner of the turbine to the rotor of the electrical generator, revolves in two babbitt-lined oil-guide bearings. One bearing is situated directly above the runner and is incorporated in the head cover. About midway between this bearing and the electrical generator is located the other guide bearing. Directly above this bearing is located the oil-thrust bearing, which carries the weight of the revolving parts of both the turbine and the rotor of the generator, amounting in all to about 145,000 pounds.

In addition to this load, the thrust bearing is capable of taking care of a considerable extra load. The downward hydraulic thrust of the runner, caused by the pressure of the water in the chamber between the upper side of the runner and the head cover, is eliminated by connecting this chamber to the draft tube by piping of large diameter.

The thrust bearing consists of an upper and a lower disk; the former is connected to and revolves with the shaft, and the latter is stationary and is supported on the foundations. Between the two disks is an annular chamber into

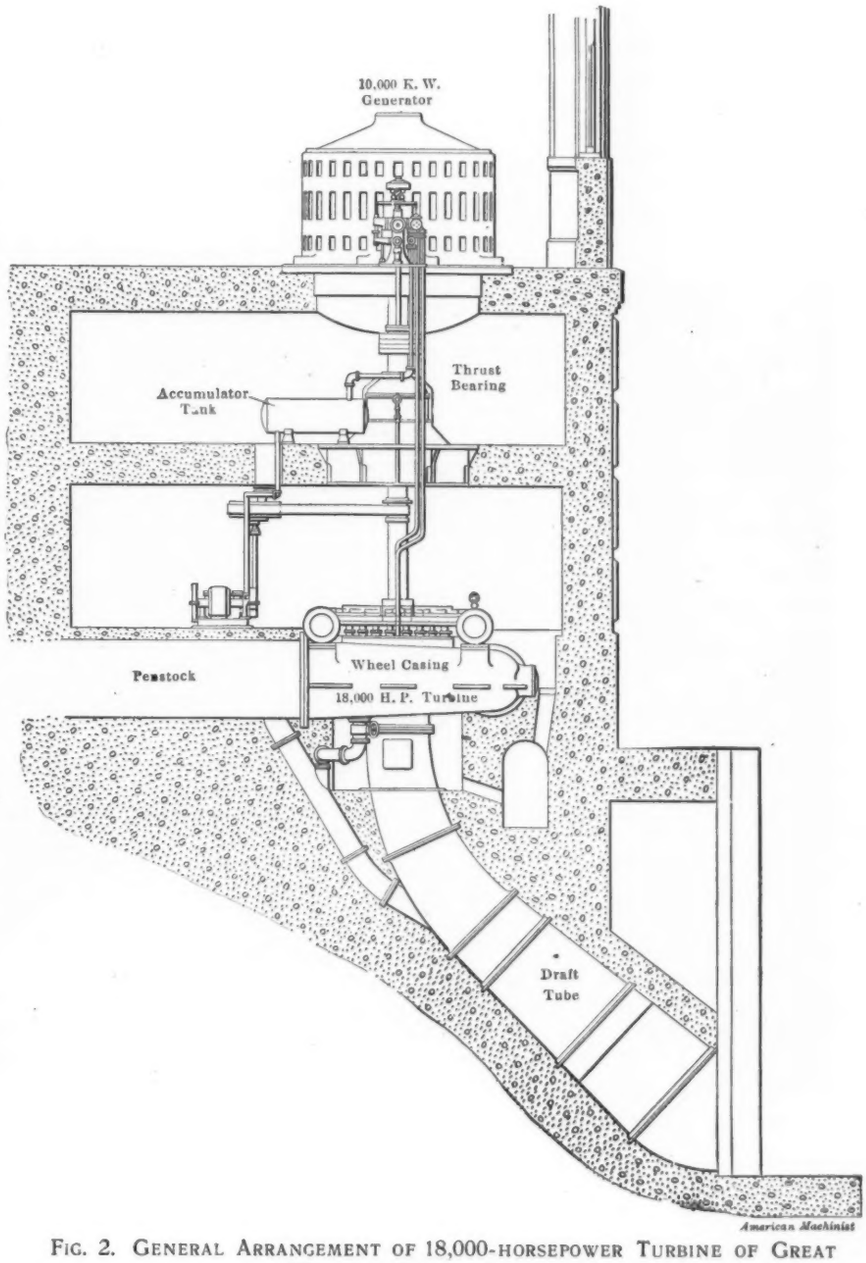


FIG. 2. GENERAL ARRANGEMENT OF 18,000-HORSEPOWER TURBINE OF GREAT WESTERN POWER COMPANY

which oil is forced at a pressure of 250 pounds per square inch, and the resulting upward thrust is capable of supporting the entire load on the bearing. The oil is supplied to the bearing by a horizontal triplex pump, operated through a belt and gearing by the main turbine shaft.

The oil which is supplied to the governor is delivered from a similar pump, driven by a direct-current motor. The oil on its way to the governor passes through a plate-steel accumulator tank, the function of which is to deliver the oil to the governor at a uniform pressure. The oil occupies about one-quarter of the cubical capacity of the tank and the remainder is filled with air under a pressure of 250 pounds per square inch. An automatic regulator in the piping between the tank and the governor keeps these conditions constant. When the turbine is operating at constant load and at normal speed, the pressure on both sides of the regulator is the same and the oil from the pump is discharged through a relief valve into the storage tank.

The thrust-bearing pump and the governor pump draw their oil from a large plate-steel storage tank, which is common to both. It has a capacity of 100 cubic feet and is located beneath the floor. Before the oil from both systems is returned to the storage tank, it is cooled by passing over coils of wrought-iron pipe through which water passes.

In order to keep the oil free from scale and impurities, brass piping is used in both the thrust-bearing and the governor systems. The governor is located alongside the generator on the generator floor, which is about 28 feet above the turbine floor.

Should for any reason the governor be out of commission, the gates of the turbine may be operated by hand by means of a small hand mechanism located above one of the operating cylinders (see Fig. 3). The operating gear is so arranged that should the governor oil system fail, the gates may be controlled by hydraulic pressure, in which case water is admitted from the wheel casing into the cylinder which is arranged for hand control.

Each of the various parts that go to make up the complete unit has been made the object of the most careful investigation—the wheel casing, the guide vanes, the runner and the draft tube—with the idea of increasing the efficiency of the unit as a whole by perfecting the various parts of which it is composed. The results obtained in the efficiency tests of these wheels have amply repaid the designers for their painstaking care in their efforts to turn out the highest class of work.

The first unit was put in operation in December, 1908, and up to the present time the vane surfaces have shown no signs of erosion. The elimination of erosion, through the proper design of the vanes, removes the only barrier to the adoption of the reaction turbine to the very high heads which, up to the present time, were considered exclusively within the field of the impulse type of wheel. Erosion is due to faulty design, and not to the high head under which a turbine operates. Of course, the danger of erosion developing is greater for high heads than for low heads. The writer is familiar with a case where the vanes of runners have been eaten through after operating for only a few months under a head of 40 feet, while in another case runners have been in operation for six years under a head of 266 feet without showing any signs of erosion.

High efficiency is not always an indication that erosion will not develop, but on the other hand, if a wheel has low efficiency when the conditions of power, head and speed are favorable to high efficiency, we know that the water is not passing through the turbine as it should and the causes of the erosion are consequently aggravated.

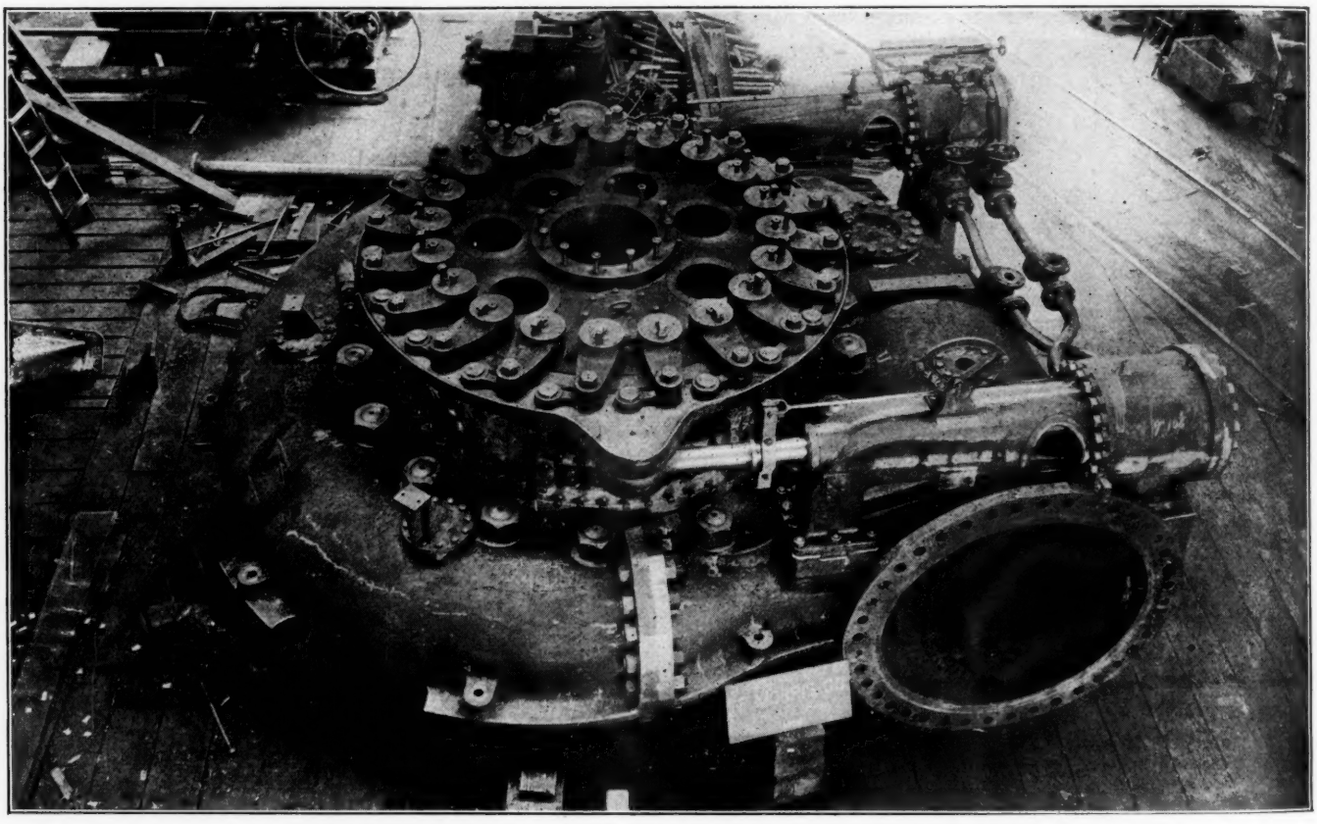


FIG. 3. 18,000-HORSEPOWER TURBINE PARTIALLY ERECTED IN SHOP OF I. P. MORRIS COMPANY, PHILADELPHIA, PENN.

THE EFFICIENCY TEST

Each of the four turbines was carefully tested for efficiency. The volume of water delivered to each turbine, under various conditions of load, was determined by taking traverse with Pitot tubes in the penstock. The position selected for the traverses was at the end of a long straight section at the rear of the power house, so as to insure that the lines of flow in the penstock were parallel to its axis and, therefore, not distorted by whirls in the water caused by bends in

the upper sections of the penstock. The plane in which the traverses were taken was one at right angles to the axis of the penstock, and, therefore, normal to the lines of flow. The plane was divided up into a number of imaginary concentric rings of equal area.

A traverse by the Pitot tube consisted in taking two readings of the velocity for each ring. All the points in one traverse fell on a selected diameter of the penstock, called the traverse diameter. An imaginary circle divided each ring into two smaller rings of equal area, and the two readings for each large concentric ring were taken at the two points where this circle intersects the traverse diameter mentioned above.

A traverse would be made with one tube on the vertical diameter, and then a traverse would be made with another tube on the horizontal diameter. A reading consisted in making one vertical and one horizontal traverse. A number of readings were taken for each setting of the gate.

The point of each Pitot tube was always kept normal to the direction of flow; therefore, the tube read the velocity head plus the pressure head for each position on the traverse diameter.

The pressure head was determined by taking the average of the readings of eight piezometer tubes, which were connected to eight equidistant points on the circumference of the penstock and at the intersection of the traverse plane with the penstock. As the planes of the openings of these tubes were parallel to the lines of flow, the readings obtained were pressure readings only.

The difference between the reading on the glass on the gage board connected to the Pitot tube and the average reading of the eight glasses connected to the piezometer openings on the penstock, gave the velocity head. Therefore, the velocity head corresponding to the velocity in the water at each position of the Pitot tube on the traverse diameter was readily obtained. Knowing the velocity head, the average velocity corresponding to each concentric ring was obtained by the use of the well known formula

$$V = \sqrt{2gh}.$$

In this manner the average velocity in each concentric ring was determined, and by multiplying the velocity by the area of the concentric circle to which it applies, and repeating this calculation for each concentric ring and summing them up by integration, the total quantity of water passing through the penstock, in cubic feet per second, was readily determined.

The Pitot tubes were carefully calibrated by checking them against a weir at Niagara Falls.

The head on each wheel was determined in the following manner: A pipe was connected to the wheel casing and led up the hill to the elevation of the head water, where it terminated in a glass tube on a vertical gage board. The head was taken as the difference in elevation between the reading on the gage board and the level of the water in the tailrace. To this amount was added the velocity head in the penstock where it joins the wheel casing.

The output from each unit was determined by using the generator as a brake. The efficiency of the generator for various loads was carefully determined at the works of the General Electric Company. The electrical output from the generators during the test was determined by taking the average readings of two sets of carefully calibrated instruments, one set furnished by the Electrical Testing Laboratories, of New York, and the other by the General Electric Standardization Laboratory in San Francisco.

During the test, the load on the generator was furnished by a water rheostat having a capacity of from 1000 kilowatts to over 10,000 kilowatts.

The maximum efficiency obtained on unit No. 1 was found to be 87 per cent. at 87 per cent. load; the maximum efficiency obtained on unit No. 2 was found to be 87 per cent. at 90 per cent. load; the maximum efficiency obtained on Unit No. 3 was found to be 88.2 per cent. at 93 per cent. load; the maximum efficiency obtained on Unit No. 4 was found to be 89 per cent. at 91.5 per cent. load.

The variation in the maximum efficiency obtained in the four units is due to the fact that the runners of the units are of a slightly different design. The wheels were designed for an ultimate head of 525 feet, which will be obtained on the completion of the dam. The present head, or the one which existed during the time of the efficiency test, is 420 feet. The above mentioned percentages of load are based on full load being 14,000 horsepower, which is the designed full load condition for the units under the present head.

Owing to the high efficiency, along with the slight overload capacity allowed for in the design of the units, it is figured that when the wheels are operated under the maximum head of 525 feet and at wide-open gate, each unit will have a capacity to deliver 20,000 mechanical horsepower to the generator which it drives. Thus, the capacity of each unit is four times that of each of the units first installed, in Power House No. 1 of the Niagara Falls Power Company, in the early nineties. The Niagara units have a capacity of 5000 horsepower each, and at the time of their installation they were the largest in the world.

Theory and Use of Hatchet Planimeter

Simplest and Least Expensive Type of Instrument for Measuring the Area of Indicator Diagrams. How to Use it and the Theory upon Which Its Operation Is Based

BY H. R. EDGECOMB

In its simplest form the hatchet or "stang" planimeter consists of a heavy wire with both ends bent down to form legs of equal length, one of which is pointed, the other flattened to a hatchet-like blade. A two-bladed penknife with one blade wide open and the other half open serves for areas within its range. To be accurate the blade must be in a line passing through the point.

London *Engineering*, May 25, 1894, after publishing a description of the instrument makes this comment: "This explanation has been written not because the instrument is of importance but because the geometry of the problem is interesting and because vague and erroneous statements have been promulgated regarding its accuracy." It is true that this instrument is one that almost does its work right and at the time the article referred to was written it was necessary to make tedious calculations to correct its errors. Various improvements have been made since that time, principally by Prof. John Goodman, of Leeds, England, which remove this difficulty and make the hatchet as reliable as it is simple.

Fig. 1 shows the simplest form as well as a number of minor variations the advantages of which are presumably self-evident. The more important improvements will be described at length later.

Theory of Hatchet Planimeter

The theory of this planimeter may be demonstrated as follows: In Fig. 2, *A B C D* is an area to be measured; *A B* and *C D* are radial from *F; B C* is an arc with its center at *G*. Placing the point of the planimeter at *C* and the blade at *E* the point is moved around the perimeter *C D A B C*. The blade, if allowed to move freely, will pass first to *F*, pivot on *F*, then move to *G* and pivot on G. During

the trip of the point around the figure the blade has gained an altitude measured by *G E*, and this hight multiplied by the length of beam *C E* gives the area of the figure *A B C D* less the area represented by the triangle *G F E*. This is proved thus: Triangle *B F C* minus *A B C D* equals triangle *A F D;* but *A F D* and *B G H* are equal and triangle *B F C* minus triangle *B G H* equals *G H C F*

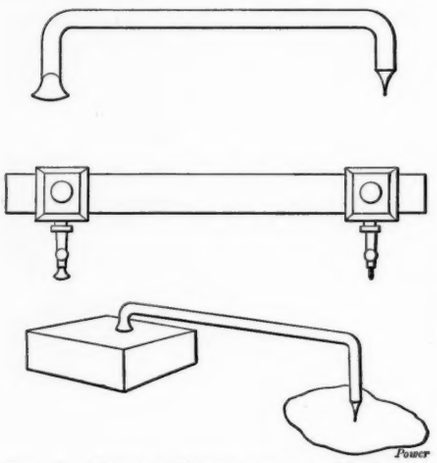


FIG. 1. SIMPLE FORMS OF THE HATCHET PLANIMETER

which is, therefore, equal to *A B C D*. Now *G E* times *C E* is the area of the parallelogram *G H C E* which, when area *G F E* is added, equals the area to be measured. This shortage in measurement is the characteristic error of the instrument.

In practical use this planimeter is used as follows: Referrings to Fig. 3, an approximate center of gravity is chosen at *A* and a line *A B* drawn to the perimeter. At right angles to *A B* a line *A C* is drawn and on this line the instrument is placed with point at *A* and blade on line *A C*. The point is made to travel from *A* to *B*, then around the perimeter of the figure

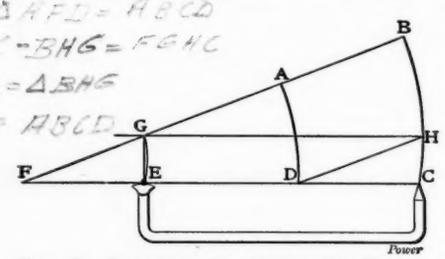


FIG. 2. DIAGRAM ILLUSTRATING THEORY OF THE HATCHET PLANIMETER

and back to *A* as shown by arrows. A slight pressure upon the blade before starting and after completing the circuit registers by two dents in the paper the altitude referred to as *G E* in the preceding geometrical demonstration. When this altitude is multiplied by the length of beam the result is the area desired minus the constant of error. Professor Goodman found by experiment that if line *A C* were at right angles with *A B* the shortage would be approximately 2½ per cent. of the area to be measured. He therefore made one of the legs of his instrument to slide so that adjustments in length of beam might be made. This arrangement, Fig. 4, was also particularly useful in the measurement of indicator diagrams, for when the legs are placed as far apart as the length of the diagram plus 2½ per cent., the hight determined is the mean hight of the card.

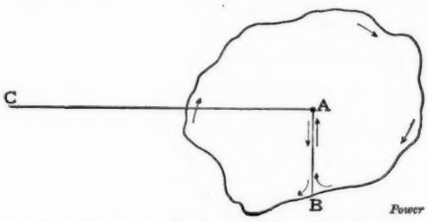
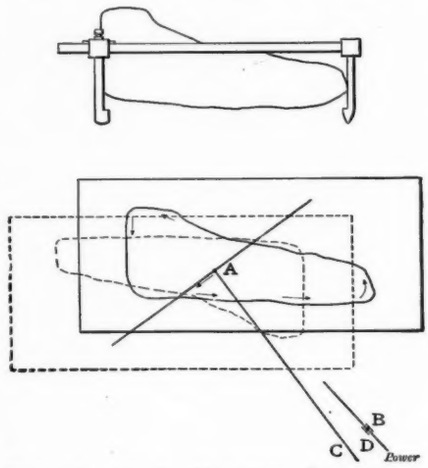


FIG. 3. USE OF APPROXIMATE CENTER OF GRAVITY WITH HATCHET PLANIMETER

INACCURACIES IN SELECTING CENTER OF GRAVITY

At this point it might be well to look into the inaccuracies resulting from selecting an approximate center of gravity and to show how these irregularities are overcome. Referring to Fig. 5, point *A* is selected as the approximate center of gravity and, the circuit having been made once, the hatchet takes its position at *C*, its starting position being at *B*. Holding the planimeter carefully in this position



FIGS. 4 AND 5. HATCHET PLANIMETER USED ON AN INDICATOR DIAGRAM

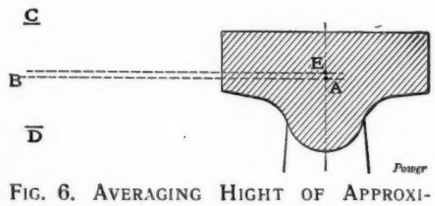


FIG. 6. AVERAGING HIGHT OF APPROXIMATE RECTANGLE FOR RIM SECTION OF A GEAR

we revolve the card through 180 degrees, using the point of the planimeter as a center. If the circuit of the figure is now made, moving the point in the opposite direction, the hatchet blade will probably not coincide with *B* but will be slightly above or below as at *D*. The altitude measurement is thus taken as the distance from *C* to the mean between *B* and *D*. It is obvious that the same thing can be accomplished by turning the instrument instead of the figure through 180 degrees. For still further accuracy it is suggested that the area be measured in four positions, 90 degrees apart, and the average of these measurements taken. If a line containing the center of gravity is given the process is simplified. Fig. 6 shows this type of figure which is very common in machine design. In this case it is only necessary to select a point in this center line and, placing the planimeter at right angles to center line trace the figure first in one direction and then in the other, taking a mean of the two hights, *B C* and *B D*.

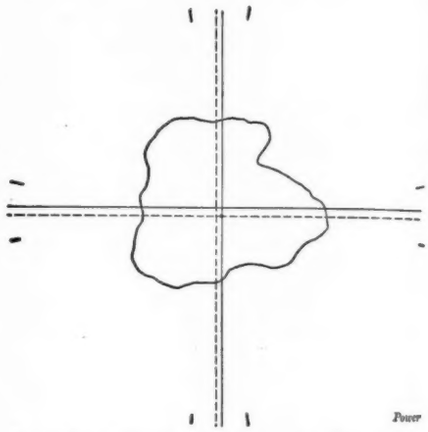


FIG. 7. AVERAGING FOR AN IRREGULAR FIGURE WITH HATCHET PLANIMETER

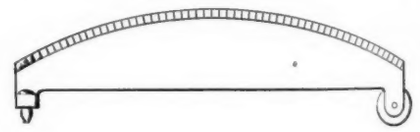


FIG. 8

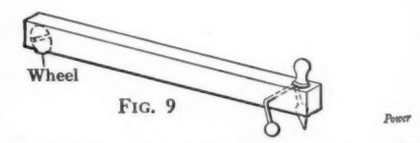


FIG. 9

MODIFICATIONS AND IMPROVEMENTS OF THE HATCHET PLANIMETER

The true center of gravity in the last case is found by projecting this mean point over to the center line. At *A* is the approximate center of gravity and *E* the exact center. If the figure is entirely irregular as in Fig. 7, a double reading is taken of each of the four positions shown, and the opposite mean points are connected. These connecting lines intersect at the center of gravity. It

is necessary that the lines passing through the approximate center of gravity be at right angles.

Improvements in the Instrument

The most important improvement in this instrument is the provision of a scale, forming part of the beam, from which direct readings for areas may be taken, Fig. 8; this arrangement was patented by Professor Goodman in 1893. He found that if the radius of the curved scale were made equal to the length of the beam, divisions equally spaced might be placed on the scale which would read area direct. This provision increases the range and insures more accurate measurements.

It is evident that a slight tipping to either side with resulting inaccuracy is unavoidable and to correct this I have made an instrument with two supporting feet placed as near as possible to the tracing point, Fig. 9. The tracing point is raised a very small amount from the paper and the wheel is held absolutely vertical. It should be said parenthetically that the drawing board or table on which the measurements are taken should always be as nearly level as possible.

In the instrument shown in Fig. 9, the pointer was made laterally adjustable so that after repeated tests on variously shaped figures the correct allowance could be made. The length of beam was 10 inches plus the allowance when the pointer was properly set and readings were taken by revolving in alternate directions as shown in Fig. 6; the measurement between dents *C* and *D* was taken with a scale reading in fiftieths. Each fiftieth indicated directly one-tenth of a square inch.

Its simplicity and consequent cheapness of manufacture makes the hatchet planimeter a desirable instrument for general use as it is within six-tenths of one per cent. as accurate as the Amsler planimeter which is recognized as standard. So far as I know it is not manufactured or sold in this country, at least not by any of the larger instrument makers.

Indicating a Steam Pipe

Probably very few engineers have ever indicated, or even thought of indicating, a steam pipe, and the following diagrams will by most people be found not less interesting than they are surprising. The diagrams were taken with an ordinary indicator screwed into a steam pipe at different positions, and actuated from the engine crosshead by a cord. The cord was rather long, but the tests were carried out by an expert in this class of work, and he has assured us personally that there is no material error due to that cause. To make the connections clear we give a plan and elevation of the pipe arrangement. The engine was a coupled compound vertical, with high-pressure cylinder, 23x36 inches, making 100 revolutions per minute. A datum line for all the diagrams was fixed by placing the indicator on top of the boiler and pulling the cord by hand. The same spring—an 80—was used as for all the subsequent tests. The line in this case was parallel, straight and steady, and showed 151 pounds above atmosphere. The indicator was then moved to a position on the pipe close to the separator on the boiler side, and the curious diagram, Fig. 2, was obtained; the cord in this case being still pulled by hand. It will be seen that there are rapid oscillations of the steam in the pipe, the pressure rising as much as seven pounds above the boiler pressure—doubtless at the moment the admission to the engine closes—and falling three pounds below it. The meaning of this diagram becomes clear when the next, Fig. 3, is studied. In this case the instrument was placed on the boiler side of the engine stop valve, and worked from the high-pressure crosshead. The diagram, of course, shows the effect of both ends of the cylinder. The admission takes place very near the ends of the diagram, and the drop shown does not synchronize with it, but is probably caused by pulsations in the pipe. This is better brought out by the next two diagrams, Figs. 4 and 5, which were

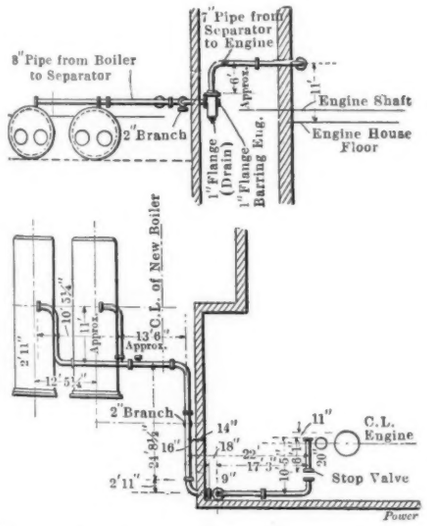
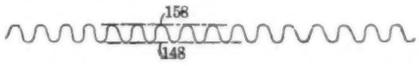


Fig. 1. Pipe Arrangement

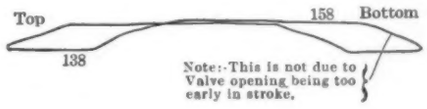


Power

Fig. 2. Indicator Cord Pulled by Hand

Power

Fig. 3. Indicator Worked by High-pressure Crosshead



Power

Fig. 4. Stop Valve Full Open

Power

Fig. 5. Stop Valve Partly Closed

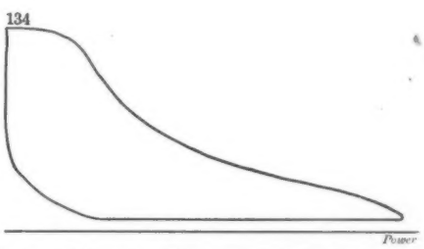


Fig. 6. Normal High-pressure Cylinder Diagram

both taken quite close to the engine, and on the steam-chest side of the stop valve. In Fig. 4 the stop valve was full open, and the diagram differs not very materially from Fig. 3. In Fig. 5, on the other hand, the motion of the steam in the pipe was arrested by partly closing the stop valve, with the result that the pressure was maintained right up to the point of admission, when it falls rapidly, rising again after cutoff. It is interesting to observe that in all three diagrams, Figs. 3, 4 and 5, a pressure in the pipe always greater than the boiler pressure is recorded. Finally, we give Fig. 6, which is taken from the engine. It shows a very clean cutoff at 134 pounds pressure. In all cases the boiler pressure was steady at 151 pounds, and the total drop between it and the engine was therefore 17 pounds. The bore of the steam pipe between boiler and separator was 8 inches, and between separator and engine 7 inches.

The stop valve employed was of the ordinary globe pattern, and, in order to test its effect on the engine, the hand-wheel was screwed down turn by turn, a card being taken after each reduction. It was found that not till the opening was less than one-eighth of the full was there any measurable effect on the diagram.—*The Engineer.*

Power for Industrial Establishments*

The Supply of Electrical Power for Industrial Establishments from Central Stations

By R. S. Hale

The general question of whether a large station can supply power more cheaply than several small ones is one that hardly admits of argument. Still, in order to satisfy myself as to whether 1000- or 2000-horsepower isolated power plants for mills diverge except in detail from the general principles that have produced the existing central station, I asked the engineers of the construction bureau of the company with which I am associated, these questions:

1. What would be the cost of power in a station that you would build today to supply about 2000 horsepower?

2. Suppose you had to supply the same at each of ten scattered points within a territory of 100 square miles, what would the power cost from a big central station?

The point of asking for both figures from one office was to be sure that both were on the same basis: that if the cost of turbines, for instance, should be taken too low, or too high, or if the cost of labor were taken too high or too low, nevertheless the same basis would be used on both sized plants and would produce no error when comparing the two propositions. Our engineers' figures are on the same basis for both small and large plants. I will not take time to present their figures in detail but they figured that ten plants of 2000 horsepower each cost $980,790 per year to deliver their power, and one large plant to deliver the same power, including distribution expenses, $739,580 per year—a saving of 25 per cent. No one should expect any other comparative results.

The real question is not whether large stations are cheaper than small ones, but the question is: Why do not the present central stations take all the present business when it can so surely be supplied at a less cost to the community if supplied from a central station?

The question is: Why are any small plants left? The real question is not as to the facts, but as to the reasons why we do not take advantage of the facts.

The figures usually assumed as the cost of supplying power to the small plants from a large central station are somewhat different from the prices the central stations will actually quote. The question is, therefore, not whether central-station power is cheaper than the power of a private plant, but whose fault is it that there should be so much difference of opinion as to the actual cost in particular cases? In my opinion, both sides are to blame. The central station has, to a large extent, failed to realize its opportunity. Also, the builders, or rather promoters, of the small plants usually figure much too low for the real commercial cost.

The first thing is to analyze the actual central-station figures and find where the money is going. In the published figures of central stations are certain large items that are nearly or entirely omitted by private plants. Billing and collecting is, for instance, a large item in central-station costs. The size of these items is obviously due to the number of small customers.

Again, for a few large plants we have figured 10 per cent. loss from the central station while actual central stations of today report 30 per cent. For a few large customers 10 per cent. is correct and the high figure for the existing central station is due to the number of small customers who use transformers at a poor load factor. For a few large plants, we figure only a small distribution expense, while the actual central station spends far more for distribution than for manufacturing, and, as before, this is because the central station has a lot of small customers.

The combination of big with little does not necessarily add to the cost of either and more usually saves on both. If a central station for a few large "wholesale" customers should add retail net work and get enough income from the retail to pay all the additional costs, it would not add to the cost of supplying the wholesale customers although the average cost per horsepower-hour delivered to all the customers would go up.

Up to within a few years, central stations have had only a retail business, and have not realized that they did not increase distribution expenses proportionately by adding a few big customers. They figured on their average costs of retail business and thought that the big business was a loss because it would not bring as much per kilowatt-hour as their average costs. Today, they are beginning to realize that it is percentage on the individual investment and not cents per kilowatt-hour that means profit.

Even today, however, few central stations realize the field that they should cover. Unjust critics are to a certain extent responsible for this, as central stations depend on popularity. A central station making 5 per cent. on its investment from the proceeds of retail business, seeing that a low kilowatt-hour price to a big mill means a 6 per cent. return on the investment for that customer and an accompanying later reduction in price to its small customers, hesitates to make the price necessary to secure the large customer because the big differential furnishes an apparent argument to those who claim that central stations favor large customers against small ones, and 5 per cent. with popularity is better than 6 per cent. with unpopularity, even if in the latter case the small customer is getting this price actually lower.

When a central station figures that doubling its kilowatt-hours by selling ten million more to a single customer will add to its distribution expenses as much as if it sold them to ten thousand customers, it makes a very serious error. On the other hand, it is sure that every additional piece of business added adds something to the expenses all along the line; in some cases more, in some cases less. There are a great many expenses of a business that must be paid but cannot be said to be part of the cost

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of any particular portion. These are what are sometimes called the general expenses, but they often have other names. For instance, the salary of the president's office boy is not obviously part of the cost of unloading coal, and yet we know that if five times as much coal should be unloaded, the expenses of the president's office would go up.

The cotton mill seldom figures any of the interest on its floating debt against cost of power, and yet the money tied up in the coal pile must be drawn from somewhere and must earn its interest somehow. Each item is in itself usually small, but in some isolated cases there are often extra expenses that run into big figures.

Just as central stations have figured the costs of adding large customers to their retail business too high, so the mill in its analysis has failed to remember that its power plant involved other expenses besides those it figured on.

I am perfectly willing to agree that the figures presented in Mr. Main's paper are correct as far as they go. We have in Massachusetts 100 to 1000 plants such as those referred to by Mr. Main. What has been the cost in others? The cost in a central station we *know*, and know for large stations and small stations. We have had bed-rock experiences for 20 years with no chance to draw on the general expenses of the rest of a mill. Any expenses which we forget to figure on come out of profits; but do you not suppose that if you got at a mill whose treasurer took a pride in his weaving room and cared little about the expense of his engine room that you would find a good deal more charged against cost of power than Mr. Main has given as the cost in the best plants?

An industrial-plant owner always says, "I am perfectly willing to pay 10, 15 or 25 per cent. more for central-station power than it would cost me to make it myself." If the costs he is thinking of were his real costs, this would be foolish, but what he really means is, "In addition to the costs that my engineer or bookkeeper figures for me, I must add 10, 15 or 25 per cent. for what they do not figure on." Now, if the engineer has included all the items, viz., interest at the same rate of profit the owner wants on all his business; depreciation, figured not on the time the plant might last but on the date when he will scrap it; taxes, insurance, coal, water, labor, repairs, rent, removal of ashes, loss due to noise, loss due to vibration, loss due to dirt, loss due to nonflexibility, loss due to extra cost of running overtime, extra cost for superintendence including the time spent in hiring and discharging engineers, purchasing coal and supplies, checking records, etc., and if after *all* the expenses are included they aggregate less than purchased power, the plant should be put in.

The projectors of isolated plants often lay stress on the special advantages of such plants for some particular case, usually in connection with the use of exhaust steam. One of the isolated-plant advocates told his client that he could use his steam three times: first, for power; second, for heating by exhaust steam; and third, for evaporating sugar or in chemical processes.

There is no question about the theoretical advantage of using the exhaust steam for heating, but if the practical advantage followed the theoretical then the central stations should be putting down small plants in the centers of cities and selling steam heat in local blocks. If the central stations find this does not pay, and practically every one of them has tried it at some time or other, then the chances are that it usually does not pay. The same argument applies to many of the other special cases.

An important difference between a small plant and a central station is that there is an actual difference in the thing supplied in two very important ways. One is quality of service. Theoretically, a small plant can often give as good service as a large one. Practically, the large one gives much better service in many ways. The steadiness and reliability of the power from a central-station power are greater; they cost more and are worth more. This is a special condition that is really more frequent than the question of steam heating. A business that is fully satisfied with cheap and irregular power at a low price can often make that quality of power itself better than it can buy a good quality of power from the central station.

A second difference is that the isolated-plant supply is inflexible, but the central-station supply is flexible. An isolated plant, if figured on depreciation of 3 per cent., must be used a quarter of a century. Even at 10 per cent., it must be used a long time; and, more than this, no plant is like the one-horse shay, it can *never* be discontinued without a loss. On the other hand, central-station supply in many cases can be discontinued at the will of a purchaser on a moment's notice.

It is true that this freedom for the purchaser can only be given at an expense to the central station. When the central station must be prepared to lose a customer at a moment's notice, or a month's notice, it cannot make its arrangements as economically as if it counted on running along exactly the same, year in and year out, as the mill that has its own plant must do in order to make the plant pay. This condition is partly taken care of by long-time contracts. If a central station can figure that its investment for a particular customer will be used for all time and will not be discontinued at some definite or indefinite date, it can supply power more cheaply. On very large business, it must get this assurance by long-time contracts; on small business by its own judgment of the future; but even with the longest and strongest contracts made with the central station, the mill is freer when purchasing power than with its own plant, since at the end of the contract it discontinues without loss, while with a plant of its own it can never discontinue without loss.

To summarize:

1. Central-station power can, except in very unusual and special cases, be supplied more cheaply than when a man in another business attempts to make power as well as to carry on his own business.

2. Central-station power is practically always better and gives the private owner more freedom and flexibility than when he ties himself to his plant.

3. The existing central stations have in the past figured the cost of their power supply in large lots too high, and have unconsciously hurt themselves and the public by attempting to charge large customers too much.

4. When central stations have made proper prices, the people who do other kinds of business have hurt themselves and the public by figuring their own costs of power too low and not charging their own time and general expense against the added business responsibility of the plant.

Applicability of Electric Power to Industrial Establishments

By Prof. D. C. Jackson

The centering of power generation into a single-generating plant for any large establishment is accompanied by economies in power generation that are of themselves appreciable, besides contributing to reliability. The question that I wish particularly to bring to your attention is: how far should such concentration proceed? Without the electrical distribution of the power, such concentration could not be adequately carried out at all. Moreover, whatever limitations still exist in the way of improving the economy by completely concentrating the power generation in any industrial establishment, exist with respect to the prime movers and not with respect to the electrical distribution of the power. Where hydraulic prime movers are to be considered, the concentration may ordinarily be made as complete as the conditions of the water supply will permit, since the charges on account of first cost of installation and the labor cost of operating practically dominate the cost of the power developed, and these may ordinarily be ex-

pected to decrease per unit of output as the capacity of the plant is increased, under conditions of equal or improved load factor.

An equivalent condition has not heretofore existed where steam prime movers have been used. Since neither labor cost nor steam economy is much improved by increasing a steam-electric generating plant over a size of a few thousand kilowatts capacity, when reciprocating engines are used, the need of extreme concentration of individual plants has not heretofore been acutely felt. But the advent of large steam turbines has altered the conditions. Plants equipped with these machines and with boilers provided with adequate labor-saving appliances may be operated with labor costs that vie with those of hydraulic generating plants equipped with machines of equal size; and the steam economies derived from the newer steam turbines are remarkably satisfactory, although the operating economies of large steam-turbine plants, either in respect to the use of labor or the use of fuel, do not seem to be exhausted within the limits of capacity yet attained in even the largest generating plants now in commission. Moreover, the first cost per kilowatt of capacity of plant, including land, buildings and machinery, falls off in an important degree for the larger steam-turbine plants, until such a plant may nearly rival a hydroelectric plant in the gross cost per kilowatt-hour of energy delivered at the switchboard, through the fact that the fuel cost in the steam-turbine plant has an offset in the charges caused by larger first cost per kilowatt of capacity of the hydraulic plant.

These considerations indicate that concentration of steam-electric generating plants will afford considerable economies when the concentration is carried much further than heretofore, provided large steam turbines are utilized as prime movers. The ultimate economy cannot be reached in a single factory plant, even when it comprises several thousand horsepower; and logical development leads beyond the present practice of concentrating the power units of each manufacturing establishment into an individual power plant. Economy and reliability in power service are both to be obtained by further concentrating such individual power plants located in a compact industrial center into one or more great central stations each of which provides power for a number of establishments.

The usual round estimate of the cost of power in machine shops and the like is $60 per horsepower per year—taking the average power during working hours, perhaps nine hours a day on the average. The cost is probably fully that large, as the power in machine shops seldom exceeds a couple of hundred horsepower and often does not exceed one hundred horsepower. The load factor is also rather low. Under more favorable conditions, large reductions may be made compared with this figure. In the case of a mill using an average of substantially 2000 horsepower, for 24 hours per day, 313 days in the year, the cost per indicated horsepower per hour may be reduced to the following figures in case a good compound-condensing Corliss engine is used and the boiler firing is intelligently supervised.

	Cents.
Fuel, oil, waste and repairs.....	0.42
Labor	0.08
Insurance (boiler, liability and fire), interest (at 8 per cent.), depreciation and taxes on power plant including building and land.....	0.15
	0.65

The cost of coal is put at $4 per ton on the cars at the purchaser's siding, and it is supposed to cost 25 cents per ton of fuel to put the coal in the power-house bunkers and to dispose of the ashes.

The above figures refer to indicated horsepower, and the cost may be increased 50 per cent. or more for the power mechanically delivered to the centers of use in the mill; in which case the cost would correspond to a central-station charge of as much as 1¼ cents per kilowatt-hour for electrical power delivered to motors of large size carefully located in the mill. When running the same plant ten hours per day instead of twenty-four, the cost would come to substantially one cent per indicated horsepower-hour, and when mechanically delivered to the centers of use, the cost of the power may reach a rate corresponding to a central-station charge of as much as two cents per kilowatt-hour. In small plants and plants with a less favorable load factor, the cost is ordinarily much higher; the illustration which I have taken relates to power generated under conditions particularly favoring a low cost per horsepower-hour for an individual industrial plant.

The mill using 10 per cent. more power at the maximum than is required on the average, and operating 313 days of 24 hours each in the year, gives substantially 78 per cent. annual load factor based on an installation of a rated capacity equal to the maximum load. If the 10 per cent. by which the maximum load exceeds the average is expected to be carried by the margin in the capacity of the machinery over regular rating, as it properly may be in cases where the extra load occurs for brief periods when the mill is cold after having been shut down, or for some similar reason, the annual load factor of the machinery is substantially 86 per cent. With such a load factor, a large turbine station can generate electrical power at a remarkably economical rate; it is three times the load factor ordinarily obtained in electric-lighting stations. Putting this mill on a 9-hour régime for 313 days in the year, its annual load factor would drop to a little over 30 per cent., and increase the cost of the kilowatt-hour. The load factors of manufacturing establishments are usually less than this, as the power consumption is generally subject to more variations than in the mill chosen for illustration.

Even with the conditions named, a large properly designed and built turbine station delivering power to a considerable number of factories ought to be able to improve a little on the power costs and add something to reliability. The requirements for heating mills and the use of steam in various manufacturing processes often make it impossible to remove the means for generating steam from the factory site, but the generation of steam for power purposes is commonly accomplished separately on account of the different pressures needed for the two purposes, and the separation is therefore a matter to be dealt with as of manufacturing convenience rather than as controlled by economy of steam generation.

Electrical distribution of power has made its way in factories of all kinds of product, on account of what we commonly refer to as its flexibility. It has proved particularly advantageous on account of its ready adaptation to delivering power wherever required, its steadiness and controllability of speed, which have contributed to increasing both the quantity and quality of product; on account of cleanliness, reliability and safety. Its use has also ordinarily proved economical from the standpoint of cost of horsepower applied to the machine shafts. The advantages of flexibility and speed control are being constantly widened by wiser designing of motors and their appurtenances, as experience extends. Economy and reliability are being additionally provided in the improved designs and more substantial construction of new power houses.

But one of the important possibilities for densely crowded industrial cities is still almost untouched. For instance, in the city of Philadelphia many tens of thousands of horsepower are used for manufacturing in establishments crowded together in city blocks, and the power is developed in separate large and small power plants located, as physical conditions warrant, in each establishment and with a minimum consideration given to economy. Several (perhaps three) large steam-turbine electric power houses, located on tide water aside from the densely occupied areas and constructed with a view to minimizing the cost of operation, could profitably supply this power at figures corresponding with its existing cost, and at the same time release for productive purposes large parts of the very valuable space now occupied by individual-factory power plants.

Central Stations versus Isolated Plants for Textile Mills

By Chables T. Main

In textile mills, the production of power is an incident or detail, and usually the cost of power does not exceed 5 per cent. of the value of the product. A saving of 10 per cent. in the cost of power, therefore, would represent a saving of not over one-half of one per cent. in the cost of the product. It can be said generally that the cost of producing power may be divided into two parts:

1. *Independent charges*, embracing fixed charges on the plant—as interest, depreciation, insurance and taxes, and, to a certain extent, repairs; and

2. *Proportional charges* (proportional to the output), including such charges as coal, labor, supplies, etc.

In general, steam plants may be said to have low independent charges, and high proportional or operating costs. Water-power plants are usually the reverse, with high fixed-charge accounts and low operating costs.

Another item which should be mentioned as affecting the cost of power is what Doctor Steinmetz calls the "reliability factor," which takes into consideration the spare machinery needed to insure continuous service.

The chief conditions which affect the cost of steam power are the cost of fuel delivered to the furnaces, the amount of power produced, the load factor in its relation to fixed charges, whether the power is continuous and uniform, or intermittent and variable, and the utilization of the waste heat of the power plant in the manufacturing processes, in the form of low-pressure steam or warm water.

The chief conditions which affect the cost of water power are fixed charges on the development, the amount of power produced in its relation to fixed charges, the load factor in its relation to efficiency of wheels, pondage and reservoir capacity, and the cost of supplementary power, if any, required to make up for the fluctuations of the water power.

In order to give a general idea of the usual costs of power under ordinary conditions in this section of the country, an analysis of the cost of power for a station of 2000 kilowatts capacity is given below. This station is similar to some which have been constructed within the last few years. It is assumed to contain two generating units of 1000 kilowatts each and no spares. This may be considered as fair average practice at present for textile plants, but it would not be tolerated for public-service plants where reliability is necessary.

In making up the cost of power, all charges have been considered except the interest charges and taxes on the cost of land. These are usually not large items in textile mills, and are variable. The cost of land for the station has also been omitted from the cost per kilowatt of the station.

In making up these costs, interest has been taken at 5 per cent.; depreciation and repairs on the apparatus for 10-hour power at 5 per cent. and on the building at 2.5 per cent.; insurance and taxes at 1 per cent., making a total of 11 per cent. on the apparatus and 8.5 per cent. on the building. For 24-hour power, the depreciation and repairs on apparatus are increased 2 per cent., thus making the total charge 13 per cent. instead of 11 per cent. A small amount is added in both cases for incidentals. These rates of depreciation would not be proper for a station where the manufacture of current was the main product as for a public-service plant, for newer and more efficient types of apparatus would make it necessary to discard apparatus which was mechanically good. This course would not be so necessary in a manufacturing plant where the saving of a small percentage of the cost of power is not of such vital importance as are some other considerations.

With a steam-engine plant, with direct-connected generators, the cost of the plant per kilowatt of capacity is about $125. The cost of power from this station with coal at about $4.25 a long ton, in the pocket, would be about $33 per kilowatt per year of 3000 hours, as a straight power proposition. This would be a cost of 1.1 cents per kilowatt-hour, and equivalent to about $24.63 per electrical horsepower per year, and about $21.50 per indicated horsepower per year.

If steam turbines are used instead of steam engines, the cost of the station will be reduced to about $105 per kilowatt capacity. The cost of power produced on steam turbines would also be reduced to about $29.50 per kilowatt-year against $33 for the engine plant. A part of this difference is made up from the reduced cost of the station and apparatus, and a part from the better economy of the turbines, which I have assumed would use superheated steam and high vacuum, which is common practice.

If steam power were generated 24 hours a day for 6 days in a week, or, say, 300 days a year, as for a paper mill and a few of the textile mills, the cost of power would be about $57.50 per kilowatt per year for the engine plant and about $53 per kilowatt per year for the turbine plant. These costs reduce to 0.8 cent per kilowatt-hour, and 0.735 cent per kilowatt-hour, respectively.

The difference in the cost for the two kinds of power is due to the fact that practically the same fixed charges are spread over a greater number of kilowatt-hours. There is also some saving in coal due to the elimination of banking of fires for a large portion of the time.

For industrial plants of the type under consideration, the load is nearly constant throughout the operating time, which means good operating conditions.

Public Service Plants

In a public-service plant, even with the same load factor as for the 10-hour textile mill, which would be high for most central stations, the operating conditions would not be so favorable as in a textile mill, as about the same amount of banking would have to be done and the prime movers would have to operate at variable loads. This latter undesirable feature would not be so serious in a large station as in a smaller one, so far as economy is concerned, as the variation could be more nearly cared for by varying the number of units and operating all of them at advantageous loads.

The cost of generating power in a public-service plant is more, other things being equal, than in a textile-mill plant of the same size having the same load factor, because of the effect of variable load toward a reduction in efficiency, and the greater cost of plant and consequently greater fixed charges per unit of output.

It should be borne in mind, however, that public-service plants are usually of very large size, and their output delivered has to compete in price with the cost of power from very small stations. This would give the advantage to the central station as far as the actual cost of making power is concerned. But there is also the cost of transmitting, distributing and selling it, and this probably forms a large part of the total charge to the purchaser of the power. The distribution, metering and billing of power in a city are also expensive. Therefore, while a central station may deliver a kilowatt-hour at the switchboard for less than one cent, it can hardly afford to sell it for that.

Some years ago, the manager of some large public-service properties testified that the cost of power to a plant of this type could not be more than one-quarter of the gross income. A representative of another company made the statement recently that it cost his company more to meter the current for their smallest customers than it did to generate it.

Use of Power Plant Waste Products for Manufacturing Purposes

It has been common practice for many years to use the byproducts, such as exhaust steam and warm water, from steam plants for manufacturing purposes and heating. It has been also common practice to take steam out of the receiver of a compound engine for these purposes. All of the exhaust of simple noncondensing engines is frequently used for manufacturing purposes. The saving by using the exhaust of a noncondensing engine which would otherwise go to

waste is large, because there is no additional steam required for the engine, unless the back pressure is increased. Any use of the steam is nearly all clear profit, and if all of it is used the only part left to charge to power is the difference in B.t.u. due to the difference in pressure, and the condensation in the engine cylinder and jackets.

There seems to be no good reason why in time the practice of bleeding turbines should not become as common as bleeding engine receivers.

Receiver Steam

Table 1 shows the amount of coal chargeable to power when certain percentages of the steam entering the high-pressure cylinder are taken out of the receiver. This table takes into consideration the effects on the economy of the engine of not passing all of the steam into the low-pressure cylinder, cylinder condensation, etc.

TABLE 1.

Per Cent. of High-pressure Exhaust Steam Used for Heating Purposes.	Pounds of Coal per One Horsepower per Hour. All Coal Charged to Power.	Net Pounds of Coal per One Horsepower per Hour after Deducting for Exhaust Steam Used.
0	1.75	1.75
25	2.06	1.50
50	2.38	1.25
75	2.69	1.00
100	3.00	0.75

If the mill did not obtain its power from steam, so that it could use the low-pressure steam of the plant for manufacturing, it would have to maintain a boiler plant of sufficient size to produce an amount of steam equivalent to that bled out of the receiver. The amount of heat or its equivalent in coal chargeable to power is represented by the amount of work done by the engine, and the losses due to the presence of the engine. The cost of generating the rest of the steam is chargeable to the manufacturing processes.

Examples of Manufacturing Plants

A few examples of the reduction in cost of power due to the uses of the by-products from the steam-engine plant, and the bleeding of steam from the receiver may be of interest.

In one colored-cotton and silk mill, the power to run the mill was about 1800 indicated horsepower and for manufacturing purposes about 25 per cent. of the steam for this was required in the form of steam from the receiver. Assuming the cost of power $33 per kilowatt-year with no bleeding, the cost chargeable to power with 25 per cent. continuous bleeding is $29.75; the saving is $3.25 per kilowatt-year. This was for the use of low-pressure steam alone. Probably another material saving could be made by using the overflow from the condenser for water for dyeing purposes.

In another mill where much more dyeing was done, requiring a large quantity of hot water, also a large amount of exhaust steam for manufacturing and heating, the cost of power if no steam and waste products had been used, would have been about $34 per kilowatt-year, but when the proper credits had been allowed for items chargeable to manufacturing purposes, the cost was reduced to about $26 per kilowatt-year, or a reduction of about $8 per kilowatt-year.

In a plain or white-goods mill, where no steam would be required for manufacturing other than warming the building and slashing, the saving to be effected by using receiver steam for those purposes would be about $2 per kilowatt-year. About three-fifths of this, or $1.20, is for heating, and the rest for slashing; so about $1.20 per kilowatt-year is the amount of the reduction which could be made in heating the buildings of an industry similar to a textile mill.

There is one plant run by a simple non-condensing and a cross-compound engine. The exhaust from the simple engine and the condensing water from the compound engine are all used in the dyeing, finishing and heating. The net cost of coal for power under the two last conditions is small.

In one mill which is run wholly by water power about 12,000 tons of coal are burned annually for dyeing, finishing and heating the buildings. If a portion or all of this mill had been run by steam power, the waste products of the steam plant would have furnished a portion of the heat required for manufacturing purposes.

The Cost of Water Power

The cost of water power depends upon a great variety of factors, but the essential feature is usually the fact as to whether the combined result of all these factors is such as to make the cost of the development per delivered horsepower a reasonably small amount, so that the fixed charges shall not be excessive. In other words, the allowable cost of water power cannot be materially more than the net cost of producing the same amount of power for the same purpose in some other satisfactory manner, usually by steam.

The cost of maintaining and operating a supplementary steam plant to make up for the shortage of power during low water, flood periods, etc., must be carefully considered, as it affects the actual cost of power delivered from the hydraulic plant. Since water powers usually have high independent charges they are more valuable for use on loads with high load factors than with low load factors, and hence are more valuable for 24-hour power than for 10-hour power.

Many modern developments are of very large size and the cost per horsepower of the plant is in some cases small. In the determination of the cost of power, the cost per horsepower of development should not be allowed to confuse or cause misrepresentation of the actual cost of power delivered. Usually the larger the development installed, the smaller is the cost per horsepower of development, but it does not follow in all cases that the cost of delivered power will be smaller per horsepower.

There are usually more elements of chance and more unknown factors in a hydraulic development than in a steam plant, and these facts should be taken into consideration and properly cared for. It is the lack of consideration of some of these items that has caused some of the water-power developments to get into disrepute. On the other hand, a development properly made and at a reasonable cost is a valuable asset and one which bids fair to increase in value if the price of coal increases in the future as in the past.

Variation in Value of Water Power

The value of a hydroelectric power to various industries will vary in approximately the same ratio as the cost of producing power in some other way, if considered as power, pure and simple, without taking into consideration other important items affecting the business, which are sometimes more vital than the cost of the power itself. The following case illustrates the value and cost of power in one particular instance:

A price of 1.2 cents per kilowatt-hour for hydroelectric power was submitted to a color textile mill. After due consideration, it was decided that the mill could not afford to accept the offer, the principal reasons being that, on account of the use of steam for manufacturing purposes and of the water of condensation for dyeing, the net cost of steam power would be less than the price of hydroelectric power, and that it was considered better for the textile company to own and control its plant, if it had the capital to build it, than to purchase current brought over many miles of pole line, and be tied up to some foreign company. The cost of power at the switchboard from the hydroelectric company for the operating time of the mill was about $36 per kilowatt-year; and for the steam plant which the mill was proposing to install this cost was estimated at about $34 per kilowatt-year, but if the power had been bought from the hydroelectric company, the mill would have had to install and operate a boiler plant nearly as large as the one required for both power and manufacturing. It was estimated that the use of the waste products from the steam plant would reduce the net cost of the power at least $8 per kilowatt-year.

Central Station Built by Several Mills

Steam central-station plants for the distribution of power to textile mills are being built and operated by the mills themselves to considerable extent, because a central station of large capacity can be run at less expense than several isolated plants, if considered for power only, without considering the other uses for steam and warm water. It is doubtful, however, if a central plant located at such a distance from the manufacturing processes as to make it necessary to forego the saving which can be made by the use of the waste steam or water can be run as economically as several scattered plants from which low-pressure steam and condenser water can be made of use. In some plants, it becomes necessary to abandon this advantage owing to the growth of the plant and the necessity of separating the power plant from the mill.

Hydroelectric Stations

There are comparatively few hydroelectric plants owned by other corporations which are supplying textile mills in the North with a portion or all of the power required by them. The reasons are that power costs more and can be sold at a greater price; the power plants of textile mills are usually large enough to make them fairly efficient in fuel consumption and fairly cheap to run in other respects; there is usually no large amount of reserve machinery, as the service is not severe, and as it is owned and controlled by the company itself it can take some chances which could not be taken by a company selling power to the mill; the power plant is only an item of the whole plant, and is so considered; it usually gives little trouble or care to the manager, and requires no additional salaries except for ordinary engineers; the depreciation is not so important as it is in a central power station, because the cost of power is a small percentage of the value of the product and there is not the necessity of change so frequently in order to get the utmost economy that there is in a station producing power only; with the mill plant, there are no large charges to be made for transmission costs and losses, selling and metering the power, franchises, administration and other items which are necessary and common to central power stations.

The most favorably situated and least expensive hydroelectric developments can make power and distribute it and sell it to plain textile mills at prices which will be attractive, but it will be quite difficult to sell at prices low enough to compete with the net cost of power to the color textile mills which use their steam to the greatest advantage for power and manufacturing purposes.

Surplus power which can be furnished for less than the whole year must be sold at low prices, as the mill must maintain its steam plant for emergency use and run it when necessary, thus adding to the cost of purchased power the fixed charges on the steam plant, and such operating costs as may be met from time to time.

Advantages to Purchasers of Electric Power

Some of the advantages to the purchaser are as follows:

In a new enterprise, in which the power plant has not already been constructed, there will be required less investment for the power plant with the purchase of current than if the power is produced by the company itself, and the manufacturing company will have more capital for other uses in its business.

Less space will be required on account of the omission of the power plant and perhaps a better arrangement of buildings can be made on that account.

There will be less care to the managers of the mill if the power is purchased than if it is produced by the mill, but in a textile mill this does not usually seem to be very serious.

The company is enabled to postpone the introduction of a power plant until some later date, and in that way is able to take advantage of any improvements in power-plant equipment which might be brought about in the meantime.

For the above reasons, I should expect that a mill would be willing to pay something more than the bare cost of power if the power were purchased from outside, but the mill should determine what the net cost would be from its own power plant, taking into consideration not only the cost of power, but also the saving due to the use of low-pressure steam and warm water for manufacturing purposes.

If power is purchased, there must usually be added the cost of running a boiler plant at the mill for heating and manufacturing purposes in making the comparison with the combined plant at the mill for power, heating and manufacturing purposes. For this reason the central station will have difficulty in contracting with large textile mills for power except under the most advantageous conditions for the central station and the most disadvantageous conditions for the textile mill.

Boiler Tubes Blow out and Injure Firemen

Splitting tubes have caused serious trouble and loss of life recently at the plant of the Flint Electric Company, Flint, Mich. The plant is equipped with a number of 350-horsepower Stirling boilers fitted with Jones underfeed stokers.

From time to time a number of tubes have let go, causing some of the boilers to be cut out temporarily for repairs, but the first serious accident occurred early Monday morning, January 31, when a tube in one of the boilers split for a distance of about 8 inches, at a point some 3 feet above the lower drum. The boiler was immediately emptied of water, and two men who were in the fire room were scalded to death.

Operations at the plant were resumed, when at 2:30 o'clock Saturday morning, February 5, a tube in the boiler adjacent to the one which had first let go, failed in exactly the same manner, scalding five men, two seriously, one of them, a boilermaker engaged in repairing the first boiler, dying later at Hurley hospital. The boiler which failed first had been in use only about one year, and was apparently in the best of condition. The second one had been in service five years. It had just been cleaned and had successfully withstood a hydrostatic pressure of 200 pounds. The pressure ordinarily carried was 145 pounds; but at the time of the accident, the load being light, there was only 120 pounds on the boiler. The night engineer had just left the boiler room and reported that three gages of water were being carried at the time.

No evidence of burning was found in any case and the tubes were not blistered. The failures did not occur at the point of highest temperature, but in every case were below this point, about 3 feet from the bottom drum, one tube only letting go.

In the second failure it was one of the extreme outside tubes that caused the trouble; a tube considerably removed from the zone of high temperature. Samples of the tubes which failed were cut out and bent flat without showing signs of weakness or overheating, indicating that it was simply a case of defective spots in the metal.

Following the second accident the management ordered the entire plant shut down until the boilers could be completely overhauled, which left the city in darkness for several days. No insurance had been carried, but it is understood that the boilers will now be insured by a reliable company.

Boiler Explosion at Crump, Michigan

Aged and Defective Sawmill Boiler Explodes, Killing Seven and Injuring as Many More. With No Inspection Double the Safe Working Pressure Was Carried

BY OSBORN MONNETT

Seven dead, one expected to die and half a dozen seriously injured, is the record of an explosion at Crump, Mich., about 20 miles northwest of Bay City, on the morning of February 10. The number of fatalities is remarkable considering the isolated locality and was the result of an unfortunate combination of circumstances which brought the men to the vicinity of the boiler just before the explosion occurred. The boiler was located in Princing's sawmill, 9½ miles from Linwood, on the Michigan Central railroad. According to one of the survivors, work had been started for the day, when owing to some derangement of the machinery, the engine was shut down. The day was cold, and as was their custom when idle, the men gathered in the fire room to take advantage of the warmth, until the mill should again start. They were grouped in front of the boiler near the fire doors when the explosion occurred, killing every man in the room, and leaving them, a mangled mass of humanity, on a pile of slabs and sawdust near at hand.

Another workman, who had just hitched up a team of horses and was standing alongside the boiler room, but outside of the building, had his head blown completely off by a flying piece of metal. The horses were blown on top of a pile of logs nearby but were uninjured. The sawmill was demolished.

The boiler was an old horizontal return-tubular affair, 54 inches in diameter by 16 feet long, built of iron plates, with single-riveted longitudinal seams, and contained fifty-three 3½-inch tubes. It was fitted with a water column with ⅜-inch steam connection and ½-inch water connection, with no provision for cleaning out the pipes, and had a 1¼-inch pop safety valve, one much too small for the size of boiler. A 15x20-inch manhole was located in the center course as indicated in Figs. 1 and 2, this being reinforced with a heavy cast-iron ring. In this course also was a dome 24 inches in diameter by 30 inches high, with the opening in the shell cut full size. The boiler was supported at the rear on a cast-iron pedestal, and in front was hung in a 1½-inch round iron sling.

Examination showed that the metal was badly crystallized and laminated, and was very brittle. The boiler had been used in that locality in various sawmills for 16 years and previous to that had been in use at a salt block near Saginaw. Some years ago new heads had been put in and were in good condition. Judging from the type of workmanship and condition of the shell, the boiler was about 40 years old. A patch 3 feet 8 inches wide by 5 feet long had been placed on the bottom of the middle course and another patch approximately

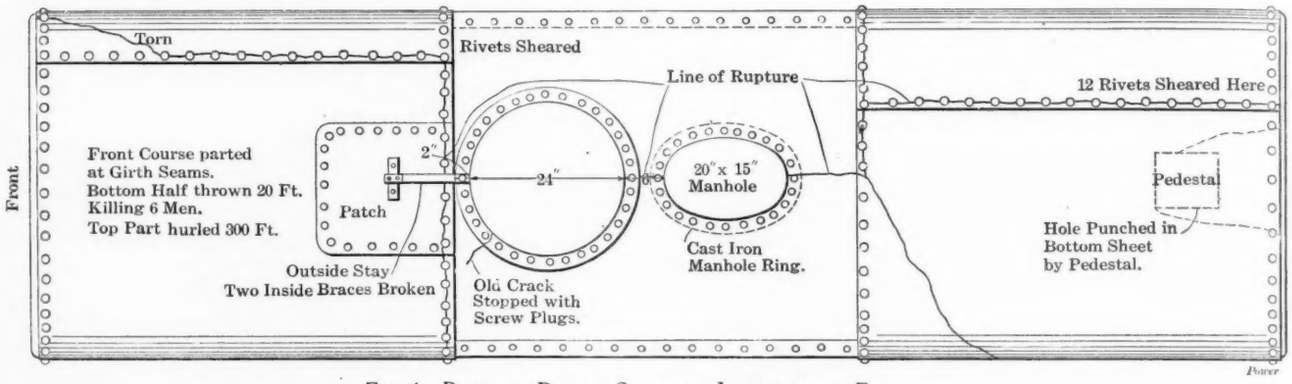


FIG. 1. PLAN OF BOILER SHOWING LOCATION OF FRACTURE

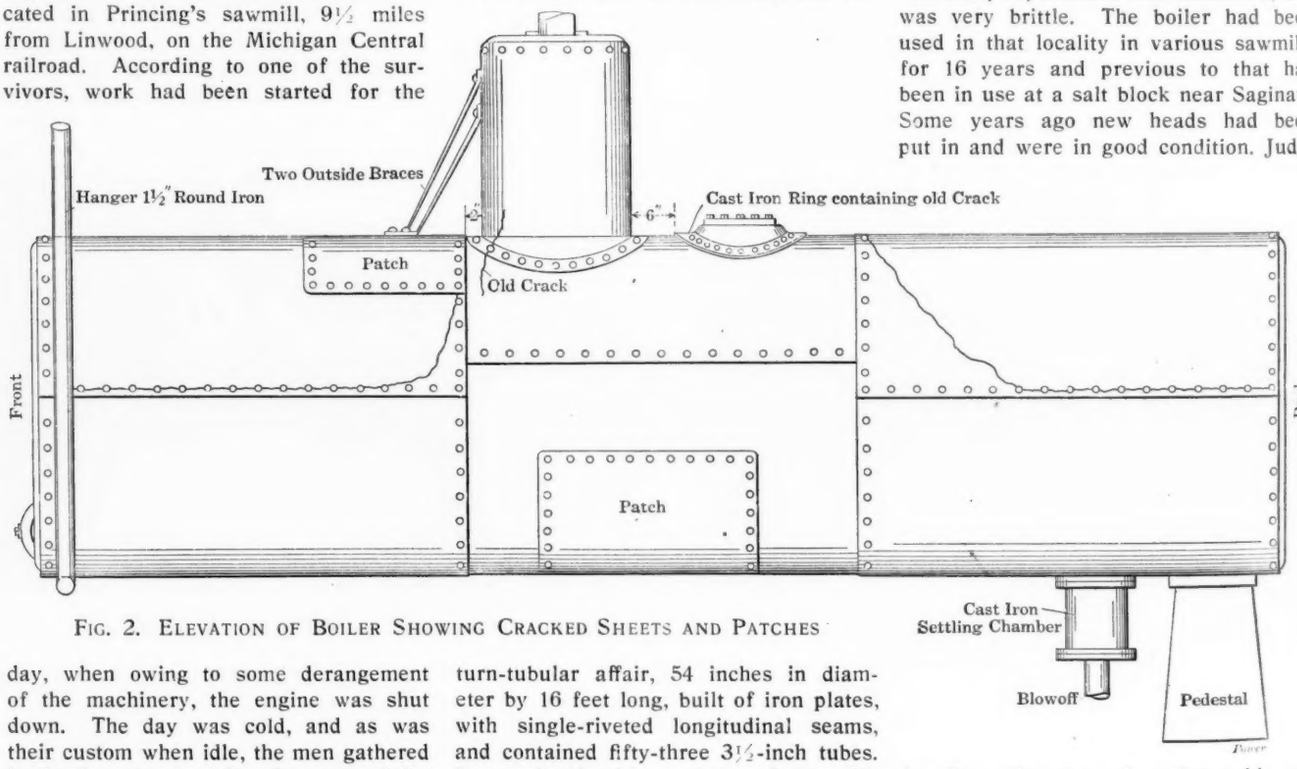


FIG. 2. ELEVATION OF BOILER SHOWING CRACKED SHEETS AND PATCHES

20 inches square was located on the top of the first course, directly in front of the dome. Two braces were broken inside the dome, and to strengthen this point two outside braces had been put on, extending from the dome to a strap of ¼x2-inch metal riveted in the center of this top patch.

For a long time past, a crack had existed in the dome, extending down into the middle course as shown in Fig. 1. This latter crack had been filled with screw plugs in the effort to repair it. The plates calipered 0.32 inch in thickness. The pitch was 1.71 inch and rivet holes 11/16 inch. The bursting pressure figuring on the longitudinal seams and assuming good metal was 284 pounds, which with a factor of safety of 6 would give 47 pounds for working pressure. For years the boiler had carried from 100 to 125 pounds working pressure, but the pop valve had recently been set at 90 pounds. It is obvious, however, that with the large openings for dome and manhole in the middle course the top center line of this course was the weakest part of the boiler.

This point had another element of weakness which was apparent after the explosion. It was found that the cast-iron manhole ring was nearly cracked through on this center line. Fig. 3 shows a section of this ring and indicates the amount of sound metal in the ring. This is also shown in one of the photographs.

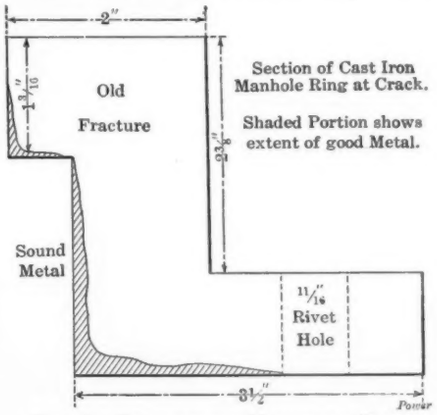


FIG. 3. SECTION OF MANHOLE RING

As was natural, the rupture started along the center line of the middle course, then down the curvilinear seam at the back course, and along the center line of this seam to the back head. The last twelve rivets in this seam were left in their holes and each showed a bad offset. This line of rivets is shown in Fig. 4.

The force of the explosion was upward and forward, the reaction causing the middle and third course to flatten out on the site of the boiler setting. Fig. 6 is a photograph of this portion of the boiler. Parting along the longitudinal seams on each side, the front portion divided in half, the upper one, together with the dome, being thrown a distance of 300 feet into an adjoining field, Fig. 7. The lower portion was projected straight forward across the boiler room, and this is the piece that killed the men grouped here.

This boiler, with its old laminated iron sheets, highly crystallized, hard and nearly as brittle as glass, its cracked and defective middle course, operating at more than twice its safe working pressure under good condition, straining the metal to the elastic limit, had been a dangerous menace for years, until from old age and general debility it was no longer able to withstand the service imposed and it gave way.

It is incidents such as this that offer the strongest argument in favor of State inspection.

Had this boiler been subject to any kind of inspection it would have been on the scrap heap many years ago.

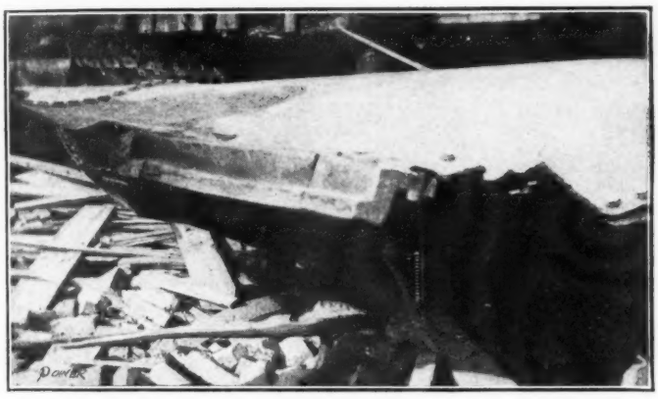


FIG. 4. CAST-IRON MANHOLE RING. CHALKED PORTION SHOWS EXTENT OF SOUND METAL

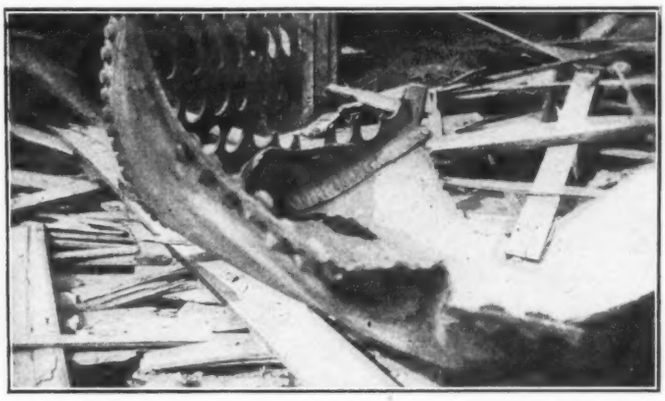


FIG. 5. ONE OF LONGITUDINAL SEAMS WITH RIVETS BADLY OFFSET

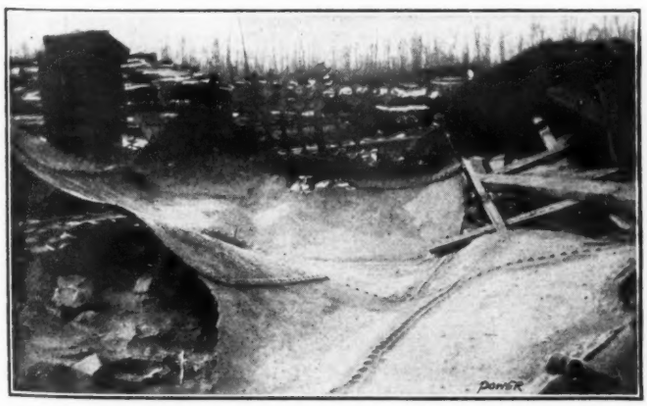
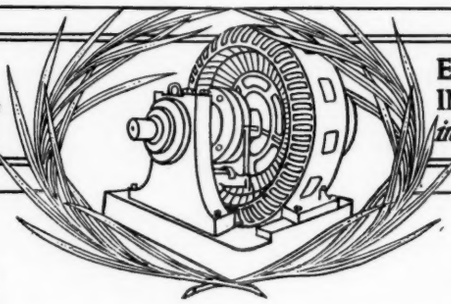


FIG. 6. SHEETS FLATTENED OUT ON SITE OF BOILER, SHOWING INITIAL RUPTURE OCCURRED ON TOP. ALSO SHOWS SINGLE-RIVETED LONGITUDINAL SEAMS

FIG. 7. UPPER HALF OF FRONT COURSE THROWN 300 FEET, SHOWING PATCH WITH STRAP FOR OUTSIDE BRACES

ELECTRICAL DEPARTMENT



ESPECIALLY CONDUCTED *to* BE *of* INTEREST *and* SERVICE *to the* MEN *in* CHARGE *of the* ELECTRICAL EQUIPMENT

Catechism of Electricity

TYPICAL FORMS OF INDUCTION MOTORS

1108. *Are all induction motors of the same general type of construction?*

There are two general types of induction motors, the squirrel-cage type and the wound-rotor type; the former is the simpler in construction. An induction motor of this type is represented in Fig. 344, a portion of the frame being shown broken away to show the interior construction.

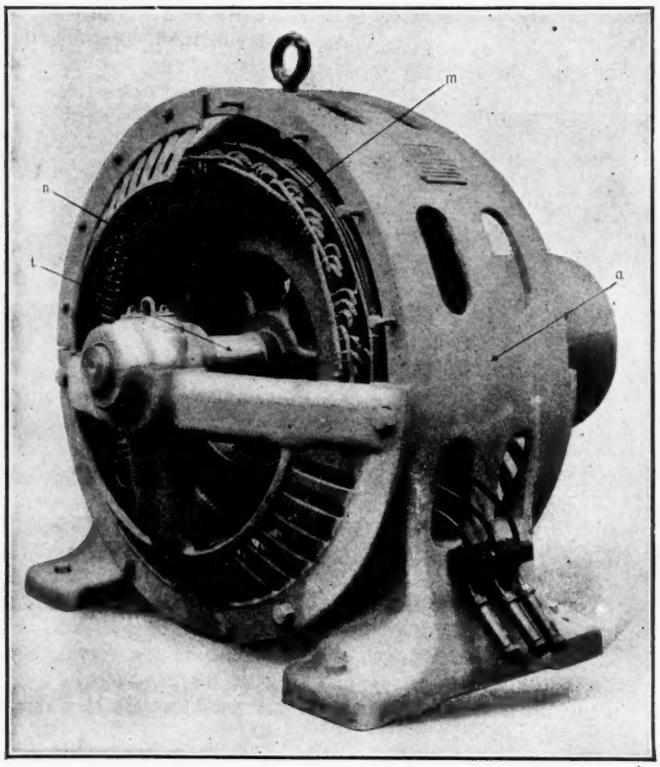


FIG. 344. SQUIRREL-CAGE MOTOR

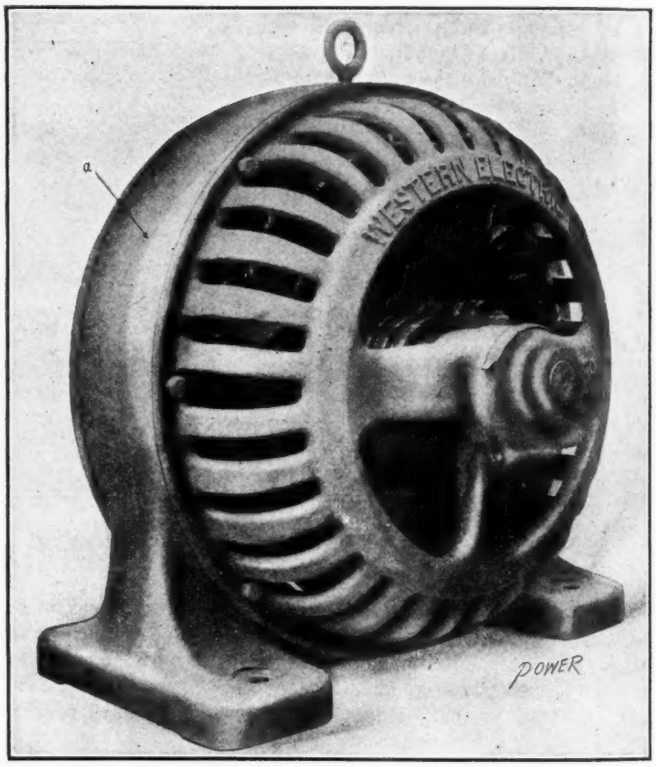


FIG. 345. SLIP-RING MOTOR

1109. *How does the wound-rotor type differ from the squirrel-cage type?*

This type is illustrated in Fig. 345. It differs from the other in that the rotor is equipped with a winding which is connected in series with a dead resistance for starting and afterward short-circuited. Slip rings and brushes are frequently required for making connection between the winding and the starting resistances.

1110. *Illustrate and describe the construction of the principal parts of the squirrel-cage and wound-rotor machines.*

The stator frames *a* of both motors are of cast iron and in one piece. The feet are broad and the frame is made so that there will be no springing; this is necessary in all induction motors on account of the small clearance between the stator and the rotor. The laminations, shown assembled at *c*, Fig. 346, are of sheet steel. The stator windings, shown at *m* in Fig. 344, are wound in forms and individually insulated before being put in the slots. The rotor of the squirrel-cage type of motor consists of a spider *n*, Fig. 344, keyed to the shaft and carrying a laminated core something like the armature core of a direct-current machine. A separate view of a rotor with inclosed ends is presented in Fig. 347. The rotor conductors consist of copper bars *b* placed in slots in the laminations *c* near the periphery. End rings *r* and *r*, formed from soft drawn copper, are securely fastened to the bars so as to give a strong mechanical joint and one of very low electrical resistance. The wound type of rotor is illustrated in Fig. 348. The ends of the winding are connected to slip rings *k*, *l* and *d*, and the current is taken from them by low-resistance brushes.

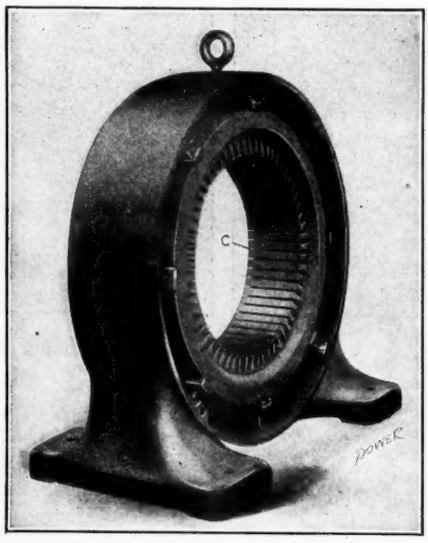


FIG. 346. STATOR FRAME AND CORE OF INDUCTION MOTOR

1111. *Are stators of different types of induction motors different also?*

No. If the supply current is the same, the stators of the different types of rotors are all of the same construction. Fig. 349 illustrates this feature. The same stator is used with any one of the three rotors shown. The stator, shown at *P*, is built up of circular laminations

keyed to the frame ribs, and held together at each end by iron rings fastened to the frame. The stator windings are form-wound and separately insulated.

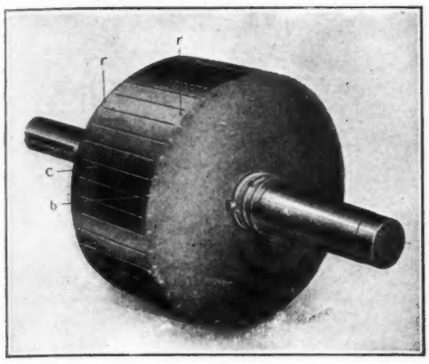


FIG. 347. SQUIRREL-CAGE ROTOR

Insulation is inserted between the coils and the iron, between the upper and lower courses of the winding and between

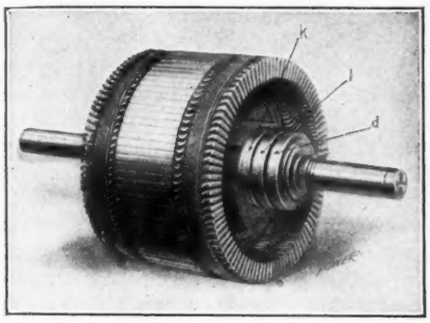


FIG. 348. WOUND ROTOR WITH SLIP RINGS

the coils of different phases. The barrel type of winding is employed.

The rotor at *S* is of the squirrel-cage type, the one at *R* is of the wound type with slip rings, and the one at *W* is of the wound type with no slip rings, the starting resistance being mounted on the triangular frame shown inside the end of the rotor core.

1112. *Describe more in detail the construction of the rotor W and the starting resistance.*

The rotor *W* is polar wound, and the starting resistance is designed to give full-load torque at starting with approximately full-load current. A greater torque than full-load torque can be obtained for starting if required, by gradually cutting out resistance. The resistance consists of cast-iron grids inclosed in a triangular cover which is bolted to the end plates holding the rotor laminations together, and is short-circuited by leaf metal brushes sliding along the inside surfaces of the grids. The brushes are supported by a metal sleeve sliding on the shaft which is operated by a lever secured to the bearing bracket and located just above the bearing. In motors of medium sizes, a rod passing through the end of the shaft operates the short-circuiting arrangement; this construction is illustrated in Fig. 350.

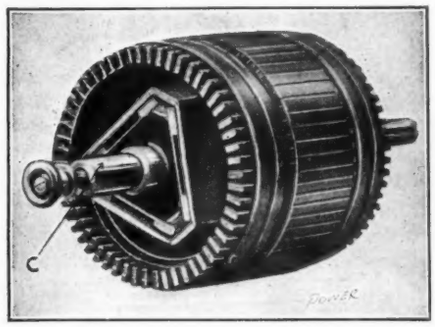


FIG. 350. WOUND ROTOR WITH STARTING RESISTANCE

For motors of over 50 horsepower, cylindrical coil resistances of German silver wound on edge are used. These coils are bolted 120 degrees apart to bosses on the spider hub, and are clamped together by a ring on their front end. Two leaf metal brushes bear directly on each of these resistances and are supported on a yoke sliding on the shaft. The operation of this brush yoke is similar to that described for the cast-iron grid resistance, a lever being employed for this purpose.

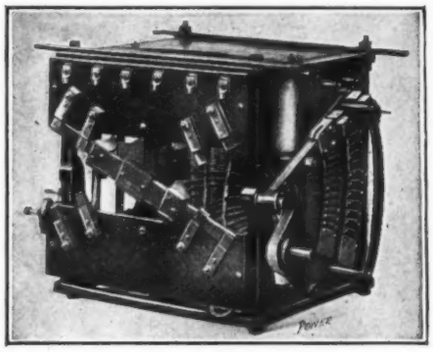


FIG. 351. CONTROLLER FOR WOUND-ROTOR SLIP-RING MACHINE

The rotor *R* is similar in construction to the rotor *W*, with the addition of the collector rings and the omission of the starting resistance, which is mounted in an entirely separate frame, as shown in Fig. 351, which illustrates a complete controller.

1113. *Explain the operation of the switches on this starting resistance.*

The controller is of the reversing and starting type. The switch shown on the front is a reversing switch, for controlling the direction in which the motor runs, and the other switch is for cutting out the starting resistance.

1114. *What are the points of difference between the different types of induction motor?*

The squirrel-cage type is the simplest in construction and the most substantial, because the rotor conductors are massive rods or bars, permanently connected to heavy rings at the ends of the core and there is only one conductor in each slot. There are no sliding contacts, brushes or switches in the machine, and it is therefore the easiest to take care of.

The wound type with the resistance mounted on the rotor (*W*. Fig 349), is the next simplest, considering the complete motor and controller as a unit, but the motor itself is not so simple and rugged as the wound type with separate controller, because the slip rings and brushes are naturally less liable to derangement than the resistance and short-circuiting switch mounted on the rotor.

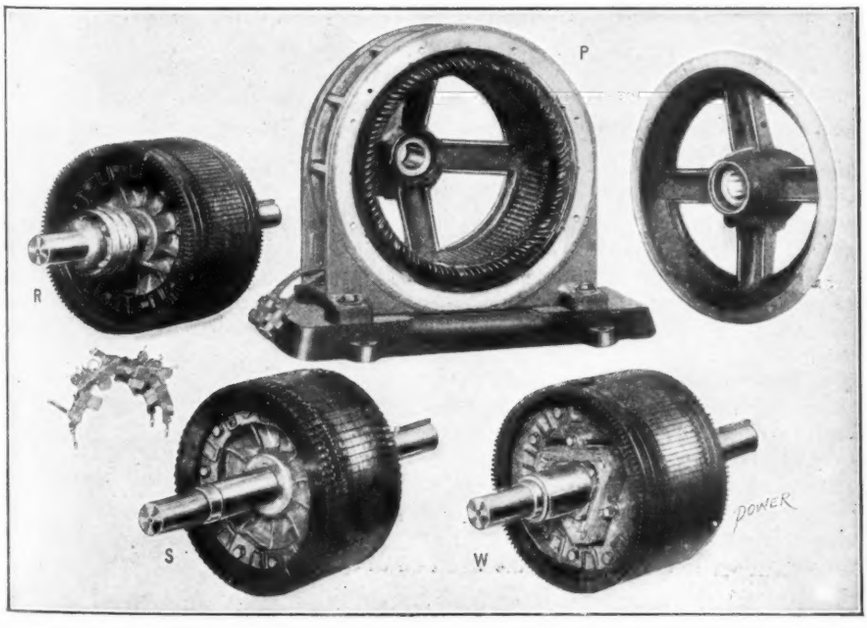


FIG. 349. STATOR WITH THREE TYPES OF ROTOR, INTERCHANGEABLE

1115. *How do the three types compare in operation?*

The squirrel-cage type requires a much larger starting current than the others and has less torque during the starting and accelerating period. The wound type with contained resistance and starting switch takes more starting current and gives less starting torque than the wound type with external controller because there is not room for sufficient resistance and switching equipment to put it on equal footing with the other motor, which is not limited in these respects.

1116. *For what classes of service should the different machines be used respectively?*

The squirrel-cage motor is best adapted to service where it can run continuously, where expert attention is not available, or where the heavy starting current is not a disadvantage. It should not be put in where a motor must start up with the load on it.

The wound types are preferable under conditions where frequent starting and stopping are required, and they are indispensable where this condition exists and incandescent lamps are supplied from the same circuit or busbars. As between the two kinds of wound-type rotors there is not much choice; the contained resistance is usually put on motors of small and medium sizes and the external resistance is used with large ones. Where a heavy load must be started, as with an elevator, the external resistance has the advantage, because of the greater space available.

Balky Excitation and Care of Commutators

I believe that Dow R. Walker's trouble, described on page 220 of POWER for February 1, was due to high mica between the commutator bars. The residual magnetism of a field magnet is very weak, and on starting up, the high mica would cause such poor contact between the brushes and commutator as to prevent this weak field from building up the voltage. He says when they pushed the armature over toward the brushes it picked up its normal voltage in about half a minute. The reason for that might easily have been that where the brushes usually make contact on the commutator the copper bars had worn down and left the high mica and just as soon as the armature was moved over, the brushes came into contact with that part of the commutator that had not been worn down, and then they made good contact with the commutator, and the machine picked up its voltage.

Again, there might have been enough grease on either the commutator or brushes, or both, to cause enough resistance to keep the dynamo from picking up its voltage, and moving the armature over would bring a clean part of the commutator in contact with the brushes and enable the machine to pick up its voltage.

WILLIAM T. GARLITZ.

McKees Rocks, Penn.

I once had a small compound-wound dynamo, using carbon brushes, which habitually gave trouble because of high mica in the commutator. Immediately after truing up the commutator and fitting the brushes all would work nicely, but a few days' run would wear the copper segments away between the mica strips just enough to make an infinitesimal opening between the brushes and the segments, leaving the mica strips supporting the brushes. This amount was so minute that when the machine was running, it only caused slight sparking, but when first starting it was almost impossible to make it build up, as the residual magnetism was too weak to generate sufficient voltage to bridge the air gap thus formed.

Pushing the armature shaft endwise with the thumb would immediately cause the machine to build up, because a small strip of the commutator would momentarily pass under the brushes on which the segments were not worn, thus for the moment eliminating the air gap and building up sufficient current in the fields to finish the work thus begun. This may be the explanation of Mr. Walker's freak "cure."

The peculiar point in the machine just mentioned was that the copper would always wear just that small amount lower than the mica and then appear to stay right there for months and give no trouble except when starting.

L. L. ARNOLD.

East Greenwich, R. I.

The "balkiness" of Dow R. Walker's dynamo was undoubtedly caused by poor contact between the brushes and commutator, because the endwise motion to the shaft could make no difference whatever in the magnetic field. If the commutator was worn conical in shape this could be easily accounted for. If, when shutting down, the armature came to rest with the endwise play of the shaft at about the limit at that end the brushes would be raised according to the increased diameter of the commutator and may have become "set" there by the cooling of the gummy substance adhering to them from the lubricant used. Then upon starting, if the belt drew the shaft to the other end of its play, the brushes may have stuck in their holders just out of contact with the commutator. Then when the sharpened stick was used to shove the shaft over, the brush contact was again made and the dynamo built up. It is a good plan on starting any direct-current machine to see that the brushes are in proper condition and make good contact with the commutator.

I do not approve Mr. Walker's plan of cutting down the mica 1/32 inch below the surface of the commutator bars, because it forms crevices to catch carbon, copper or other dust which is apt to cause sparking or short-circuits between the bars. If the copper bars get burnt or eaten away from the insulation, I should advise the use of a sandstone or sandpaper to smooth the commutator surface. A commutator is in its best condition when perfectly round and concentric with the shaft and its face is square across, and smooth and straight.

CHARLES F. CLARK.

Hartwick, N. Y.

It seems to me that Mr. Walker's exciter failing to build up readily was due either to high mica or to the commutator polish used getting gummed up and hard on the brushes. Pushing the shaft over would help to knock it off some or, if the trouble was high mica, bring the brushes to a smooth place on the commutator. I have tried pushing on the belt to set up end play, which has the same effect, of course, as holding the shaft over with a stick. Another remedy is to push hard with both hands on brushes of opposite polarity at the same time; you will then feel it when the machine picks up. A compound-wound exciter will pick up easier under load than a shunt-wound machine.

Cutting the mica below the copper would be all right if dirt did not fill in the cracks and make trouble. Sandpaper the commutator when cold and there will be no high mica; if sandpapered when warm, the copper will shrink below the edges of the mica in cooling and when next started the brushes will give trouble until the running temperature is again reached.

I have no use for the several kinds of commutator polish that are to be had in stick form. Scrape off the copper plating from back of a carbon brush and apply a little oil from time to time; it will feed through to the front as fast as needed. Better still, boil the brushes in parraffin.

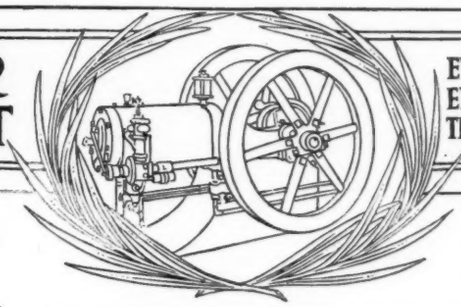
V. L. BALLOU.

Shirley, Mass.

The Edison Electric Company, of Los Angeles, it is reported, has just floated a loan of $30,000,000 and expects to put in a plant as large or larger than the Redondo plant.

The only man who never makes a mistake is the man who never does anything.

GAS POWER DEPARTMENT



EVERY THING WORTH WHILE *in the* GAS ENGINE *and* PRODUCER INDUSTRY WILL BE TREATED HERE *for the* USE *of* PRACTICAL MEN

Development of Producer Gas Power in the United States

In Bulletin No. 416, issued by the United States Geological Survey, Prof. R. H. Fernald has presented a mass of extremely valuable data on the subject.

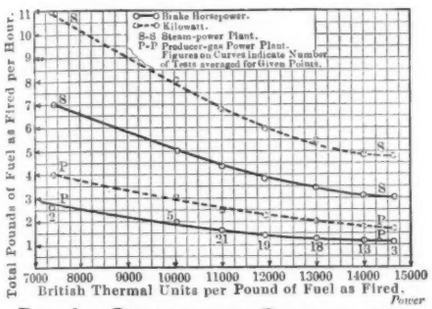

Brake Horsepower.
Kilowatt.
S-S Steam-power Plant.
P-P Producer-gas Power Plant.
Figures on Curves Indicate Number of Tests averaged for Given Points.
Total Pounds of Fuel as Fired per Hour.
British Thermal Units per Pound of Fuel as Fired.
Power

FIG. 1. COMPARATIVE RESULTS FROM FUELS USED IN STEAM AND GAS PLANTS

Table 1 herewith is taken from the bulletin; it gives the principal particulars relating to the gas-producer tests. Fig. 1, from the same bulletin, gives the comparison between the results obtained with the producer-gas plant and those from a noncondensing steam plant consisting of a 250-horsepower single-cylinder Corliss engine belted to a Bullock direct-current dynamo and supplied with steam from two Heine boilers. The gas-power plant comprised a 250-horsepower Taylor pressure producer and a Westinghouse vertical engine with three single-acting cylinders, each 19x22 inches, belted to a Westinghouse direct-current dynamo.

Especial attention is called to the fact that several low-grade coals and lignites that have proved of little value or even worthless under the steam boiler have given excellent results in the gas producer.

The ratios of the total fuel per brake horsepower-hour required by the steam plant and producer-gas plant, under full load, not counting stand-by losses, as presented in the chart, were derived from 75 coals, six lignites, and one grade of peat (Florida). The curves show graphically the greater economy secured from the 75 bituminous coals and six lignites when used in the gas producer instead of under the steam boiler. The results of the tests are officially reported on the basis of switchboard horsepower, but in order that they may be of more practical value they are given here on the basis of brake horsepower and kilowatts—the efficiency of the electric generator and belt in each plant being assumed at 85 per cent.

TABLE 3. COST OF PRODUCER-GAS ENGINES.

Horsepower.	Cost F.o.b. Factory.	Cost of Erecting.	Foundation.	Cost of Foundation.	Cost of Engine Erected, Including Foundation.	Cost per Horsepower. F.o.b. Factory.	Cost per Horsepower. Erected, Not Including Foundation.	Cost per Horsepower. Erected, Including Foundation.
			Cubic feet.					
20	$1,100	....	.....	$50	$1,150	$55.00	.....	.....
55	.....	....	.....	.....	2,400	.....	.....	$43.70
60	2,800	....	350	105	.....	46.70	.....	.....
60	2,900	....	.....	150	.....	48.40	.....	.....
75	3,610	$175	375	150	3,933	48.10	$50.50	52.40
80	.....	....	.....	.....	3,300	.....	.....	41.20
80	3,400	....	.....	.....	.....	42.50	.....	.....
80	3,250	....	.....	.....	.....	40.70	.....	.....
80	3,830	....	.....	.....	.....	47.90	.....	.....
85	4,150	....	.....	.....	.....	48.90	.....	.....
85	3,550	....	.....	.....	.....	41.80	.....	.....
100	4,300	....	.....	.....	.....	43.00	.....	.....
100	4,925	....	.....	.....	.....	49.25	.....	.....
110	4,950	....	.....	225	.....	45.00	.....	.....
110	4,960	....	.....	.....	.....	45.10	.....	.....
110	5,100	....	.....	.....	.....	46.30	.....	.....
112	4,200	....	.....	.....	.....	37.50	.....	.....
125	5,450	....	.....	.....	.....	43.60	.....	.....
130	5,250	....	.....	.....	.....	40.40	.....	.....
135	6,600	....	.....	.....	.....	48.90	.....	.....
150	6,200	....	.....	.....	.....	41.30	.....	.....
160	5,500	....	.....	.....	.....	34.40	.....	.....
160	6,100	150	2,000	520	6,770	38.10	39.00	42.30
185	7,800	....	.....	.....	.....	42.20	.....	.....
210	8,600	....	.....	.....	.....	40.90	.....	.....
250	6,650	150	2,160	560	7,360	26.60	27.20	29.40
300	10,500	....	.....	.....	.....	35.00	.....	.....
400	12,000	....	.....	.....	.....	30.00	.....	.....
400	12,800	....	.....	.....	.....	32.00	.....	.....
600	17,400	....	.....	.....	.....	29.00	.....	.....
1,000	33,750	300	.....	.....	.....	33.75	34.00	.....
2,000	64,850	875	5,400	1,400	67,125	32.43	32.86	33.56

TABLE 1. SUMMARIZED ITEMS RELATING TO FUELS TESTED IN GAS PRODUCER AT ST. LOUIS, MO., AND NORFOLK, VA.

	Bituminous Coals.				Lignites.				Peat.*
	No. of Tests.	Average.	Maximum.	Minimum.	No. of Tests.	Average.	Maximum.	Minimum.	
B.t.u. per pound:†									
As fired	127	12,280	14,674	8,735	18	8,350	10,685	6,970	8,127
Dry	127	13,150	15,073	10,489	18	11,290	11,686	10,321	10,289
Cubic feet of gas per pound:†									
As fired	85	60.50	100.80	37.00	7	35.80	45.90	26.10	30.30
Dry	85	64.70	103.50	40.90	7	45.70	52.80	38.80	38.30
Pounds per square foot of fuel bed per hour:†									
As fired	95	7.64	11.84	4.67	10	12.30	14.79	8.46	15.20
Dry	95	7.13	10.44	4.56	10	9.13	12.22	7.56	12.00
Pounds per brake horsepower-hour:†									
As fired	92	1.36	2.05	0.84	10	1.99	2.75	1.48	2.57
Dry	92	1.26	1.81	0.82	10	1.63	2.02	1.35	2.03
B.t.u. per cubic foot of standard gas	124	152.1	176.0	126.6	18	158.4	188.5	125.3	175.2
B.t.u. per brake horsepower-hour (full load)	84	11,300	12,514	9,510	7	11,081	11,810	9,700	12,840
Pounds of tar per ton of fuel as fired:									
Water not extracted	43	380.8	745	130	9	175	289	66	.....
Water extracted	130	310.0	624	92	1	110	110	110	.....
Composition of fuel:									
Moisture	130	6.83	16.69	1.43	18	26.60	39.56	8.51	21.00
Volatile combustible		33.06	42.46	9.70		31.40	38.41	25.54	51.72
Fixed carbon		49.80	73.70	31.19		32.60	45.69	23.80	22.11
Ash		10.32	23.44	2.77		9.53	15.47	2.74	5.17
Sulphur		2.41	‡7.36	0.28		1.29	4.88	0.47	4.45
Composition of gas:									
Carbon dioxide (CO_2)	130	9.84	.....	.....	18	10.55	.....	.....	12.40
Oxygen (O_2)		0.04	.....	.....		0.16	.....	.....	0.00
Ethylene (C_2H_4)		0.18	.....	.....		0.17	.....	.....	0.40
Carbon monoxide (CO)		18.28	23.89	11.93		18.72	25.20	13.90	21.00
Hydrogen (H_2)		12.90	18.60	2.81		13.74	19.30	9.20	18.50
Methane (CH_4)		3.12	.....	.....		3.44	.....	.....	2.20
Nitrogen (N_2)		55.60	.....	.....		53.22	.....	.....	45.50

*One sample of peat only.
†90 to 100 per cent. load, 30 to 50 hours.
‡A mixture of California lignite and cinders contained 8.1 per cent. of sulphur.

Table 2 gives the minimum, maximum and average ratios of fuel consumption for the gas and steam plants. The figures for the producer-gas tests include not only the coal consumed in the gas producer, but also the coal used in the auxiliary boiler for generating the steam necessary for the pressure blast—that is, the figures given include the total coal required by the gas-producer plant.

Regarding initial costs, Mr. Fernald says that an examination of many figures from various builders indicates that complete producer and engine plants of about 4000 or 5000 horsepower cost about the same as first-class steam plants of equal power output, but with smaller installations the steam plant continues to be less expensive to put in. Tables 3 and 4 present such figures as he has been able to obtain for publication. Considerable variation will be noticed in the prices given for plants of the same rated capacity. In some cases this difference is warranted by a difference in the "quality." In others it is due to a difference in the number of units installed to make up the total required horsepower or to different requirements for auxiliary equipment.

TABLE 4. COST PER HORSEPOWER OF PRODUCER-GAS INSTALLATIONS.

Horsepower.	Gas Producer and Engine Erected, Exclusive of Foundations.	Gas Producer and Engine Erected, Including Foundations.	Complete Plant, Exclusive of Buildings.*	Complete Plant, Including Buildings.*
20	$105.00	$108.50	.....	.....
25	62.50	.....	.....	.....
25	115.00	.....	.....	.....
50	86.00	.....	.....	.....
60	69.50	74.50	.....	.....
75	75.00	.....	.....	.....
75	86.50	.....	.....	.....
80	62.00	.....	.....	.....
100	67.00	.....	.....	.....
110	60.50	68.00	.....	.....
110	62.50	.....	.....	.....
125	65.00	.....	.....	.....
125	90.00	.....	$100.00	.....
150	70.00	.....	.....	.....
200	67.00	.....	.....	.....
250	65.00	68.00	79.00	$93.00
300	58.00	.....	.....	.....
500	.....	.....	84.40	.....
1,000	55.50	.....	69.50	79.50
2,000	46.00	47.50	53.50	63.50
2,800	.....	.....	.....	76.00
4,000	.....	.....	.....	69.00
4,000	.....	.....	.....	72.00
4,000	.....	.....	.....	77.50
4,800	.....	.....	.....	72.00
4,800	.....	.....	.....	79.50
5,500	.....	.....	.....	70.00

*Includes producer, engine, electric generator, piping, and auxiliaries, all erected, with suitable foundations.

TABLE 2. RATIOS OF FUEL USED IN STEAM AND GAS PLANTS.

Average ratio, coal as fired per brake horsepower-hour under boiler to coal as fired per brake horsepower-hour in producer	2.7
Maximum ratio, coal as fired per brake horsepower-hour under boiler to coal as fired per brake horsepower-hour in producer	3.7
Minimum ratio, coal as fired per brake horsepower-hour under boiler to coal as fired per brake horsepower-hour in producer	1.8
Average ratio, lignite and subbituminous coal as fired per brake horsepower-hour under boiler to lignite as fired per brake horsepower-hour in producer	2.7
Maximum ratio, lignite and subbituminous coal as fired per brake horsepower-hour under boiler to lignite as fired per brake horsepower-hour in producer	2.9
Minimum ratio, lignite and subbituminous coal as fired per brake horsepower-hour under boiler to lignite as fired per brake horsepower-hour in producer	2.2
Average ratio, peat as fired per brake horsepower-hour under boiler to peat as fired per brake horsepower-hour in producer	2.3

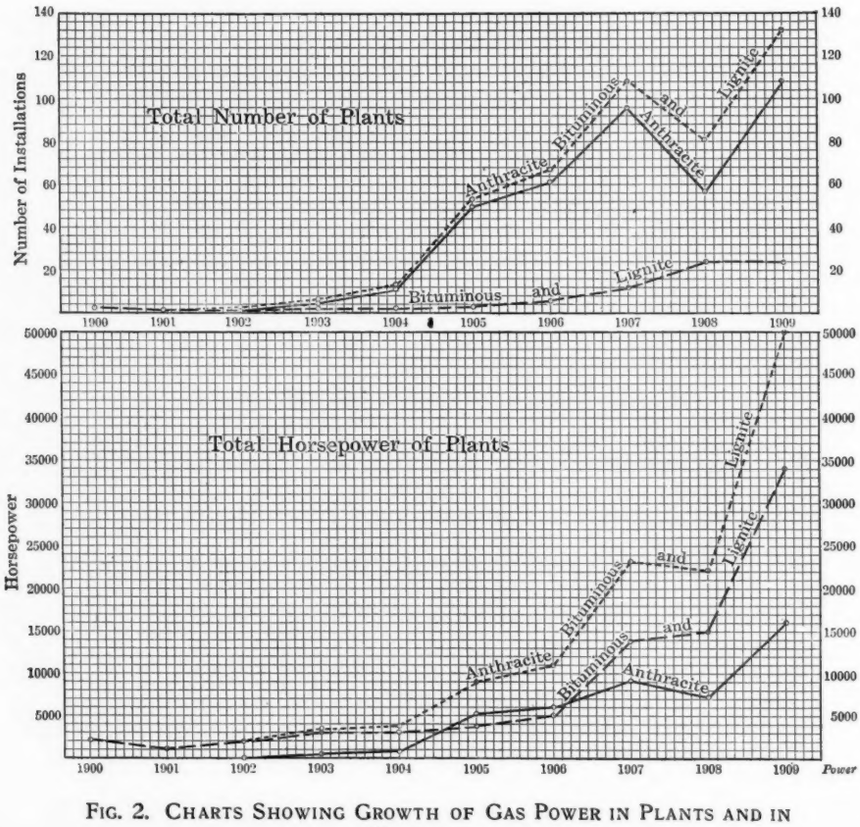


FIG. 2. CHARTS SHOWING GROWTH OF GAS POWER IN PLANTS AND IN HORSEPOWER

OVERRATING

Among the difficulties in the way of the proper development of producer-gas power, special attention is called to the overrating of producers. "It is exceedingly gratifying to note," says Mr. Fernald, "that this point is at last recognized by at least one" producer builder. This tendency to overrate producers, he states, has been especially prevalent among the builders of suction plants. In inspecting a large number of installations throughout the country this weakness has repeatedly attracted attention. It has been observed frequently that a plant using anthracite fuel of good quality will present no operating difficulties when working up to 50 or 75 per cent. of the rated capacity of the producer; but if the producer is forced to its full rating for any length of time, clinkering and other operating difficulties are encountered. This overrating has come about naturally from early attempts to follow European practice as to fuel consumption, before it became known that American coals could not be handled like European coals.

GROWTH OF THE INDUSTRY

Although a few scattered installations were made prior to 1900, the period of systematic and general application of producer-gas power seems to have begun in this country within the past six or eight years. The dates of installation of many plants are not ascertainable, so that the exact rate of the growth of the industry cannot be determined. The relative rate, however, is shown approximately by Fig. 2. The figures from which the chart was plotted were taken from 375 installations; those for 1909 cover only the first five months of the year.

CORRESPONDENCE

Effect of Small Load on a Producer

In a recent issue of POWER a reader stated that his engine, after running on a light load for awhile, took "the bit in her mouth." Now, much depends on the duration of the light load; a momentary shifting of the load from the engine I have found to have the effect of enriching the gas, the producer seemingly recuperating and furnishing a better quality of gas. If, however, the load is left off, for, say, a half hour, the fire becomes deadened to such an extent that the gas is not good and the rate of gasification falls below a workable figure. I know of an engine running on producer gas which is not shut down during the noon hour. The load, however, is not taken off entirely, and at 12:15 half of the load is resumed, the balance coming on at 12:30. It developed that when the load was taken off, there was less steam drawn through the fire, resulting in a tendency for the hot coal to cake into a solid mass; it was also discovered that there was an appreciable decrease in the temperature of the hot zone of the fuel bed. Poking the fire is the obvious remedy for the caking, but great care should be exercised not to poke too much as steam is likely to be drawn through too liberally.

"Taking the bit in her mouth" may mean running away, and this may be caused by a shifting of the load, but probably what the writer meant (provided the engine is hit-and-miss governed) was that the engine took a charge every time, without missing any explosions.

Sometimes decreasing the amount of air at the mixing valve at the engine may help matters some, provided, of course, the trouble is due to the gas being "diluted" too much by excess steam, and in this latter case advancing the spark (making it earlier) will help considerably.

WESLEY MCARDELL.

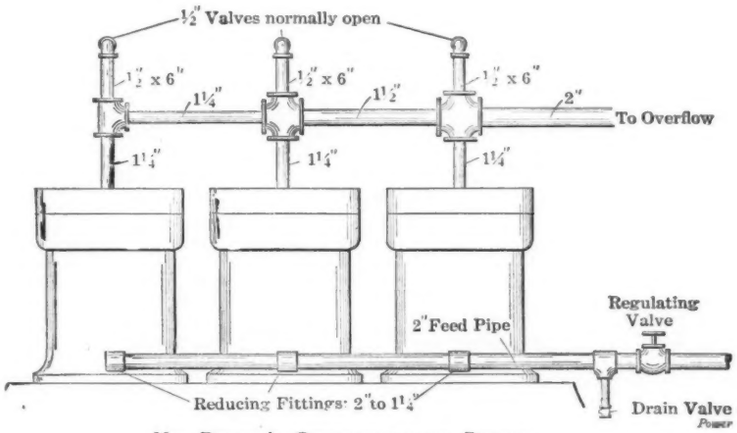
Brooklyn, N. Y.

Gas Engine Cooling Water

In his article on page 1003 of the December 14 issue, H. W. Jones mentions having trouble with the exhaust pipes of gas engines. If he will run his engines without putting water in the exhaust pipes I think his trouble will disappear.

Mr. Jones thinks the cooling water should enter at the cylinder head of a vertical engine and discharge at the crank end. It doesn't seem possible that anyone would want the coldest water to hit the hottest part first. We tried this once, but we never will again. It was on Diesel engines that we tried it.

Inclosed you will find a sketch of a good way to pipe up cooling water. By this method the pressure is retained back of the main feed valve and kept off the packings in the water jacket. The water jacket is always full and there is no chance of siphoning or becoming air bound. I have applied this method, using city water at 135 pounds pressure, and yet had only gravity pressure from the overflow pipe into the funnel. The pipes specified are large enough to keep cylinders of 150 horsepower each cool.



MR. ROCHE'S COOLING-WATER PIPING

JAMES ROCHE.

Claremont, N. H.

How Can the Diagram Be Improved?

I am of opinion that the diagrams shown by Mr. Parmely in the January 11 issue [reprinted here], could be bettered by reducing the clearance between the exhaust-valve spindle and the actuating lever, thus opening to exhaust earlier and closing later. This is possible on most makes of engines by adjusting the length of the pusher rod.

The diagram of Fig. 2 is rather deceptive because the dotted line *a—b—i*, representing earlier exhaust opening, appears to have been given a longer stroke than the original full line traced by the indicator. It would have been easier to comment upon the diagram had Mr. Parmely been able to give the valve settings, but the exhaust certainly appears to close far too early. By making it close, say, 10 degrees late (with consequent early opening), the exhaust line should drop to, or even below, the atmospheric line at the end of the in-stroke.

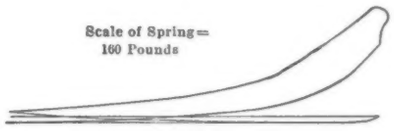


FIG. 1

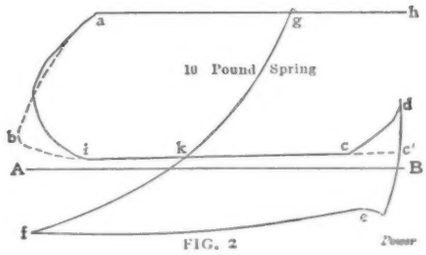


FIG. 2

According to my experience the best valve settings for an engine of the type and size referred to are as follows:

Inlet opens 3 degrees early.
Inlet closes 25 degrees late.
Exhaust opens 45 degrees early.
Exhaust closes 10 degrees late.
Ignition takes place 18 degrees early on full load.

By the way, the piston speed of this engine, 938 feet per minute, seems undesirably high.

JOHN S. LEESE.

Manchester, Eng.

A paper by Féry and Chéneveau, recently read in this country, has very direct bearing on the possibility of improved efficiency of incandescent lamps. So long as one depends for efficiency entirely upon elevation of temperature, even the best known materials have very serious iimitations. Further improvements have been closely bound up in the question of increased specific radiation. That tungsten and tantalum lamps give higher specific radiation than the older forms has been quite clearly shown by a number of experimenters. Nothing has as yet been published, however, which appears so definitely to show the amount of such improvement as the paper mentioned above. Starting with Stefan's law for carbon lamps, the authors have gone on and enunciated an exponential relation between the luminous intensity and the energy which they have verified within wide limits. They appear to have shown that for the carbon lamp the luminous intensity is proportional to the cube of the energy only through a narrow range, the real law connecting the two being the exponential one.—*The Engineer.*

A stop valve should never be opened or closed suddenly.

FROM READERS *with* SOMETHING TO SAY

PRACTICAL INFORMATION *from the* MAN *on the* JOB: A LETTER GOOD ENOUGH *to* PRINT *is* GOOD ENOUGH *to* PAY *for*

In Weakness There Is Strength; Sometimes

In many cases of engineering, safety is found in the weakness of special parts, designed to protect other and more expensive parts.

Mrs. Casey remarked, that "If it werr'nt fer Pat's being a bit sick after being in his cups, sure he'd be the divil to handle."

The practice of protecting the whole structure against destruction by the designed failure of a part easy of replacement might be carried farther than it is if designers had an eye to economy for the users of machines rather than to keeping their own shops full of repair work.

The smashing of high-speed engines might be almost entirely eliminated if they were all provided with a breaking part of large area easily replaceable, as is the practice of but one or two builders.

In this respect I want to point out how it is possible, and desirable, to strengthen the average flywheel by weakening a part of the rim structure.

We are told that the end has been reached in the efficient strength of cast-iron flywheels because added material adds also a like amount of stress and leaves the designer nothing to strive for but increased efficiency of joint; and as this has been brought about up to the 110 per cent. mark (see POWER of May, 1907), let us see what more can be done.

The average heavy balance wheel would stand more speed if the links were taken out of the rim joints and planed off one-third, reducing their cross-sectional area 33⅓ per cent. We are told that the strength of a wheel is the strength of the rim, no account being taken of the arms, because most arms press outward against the rim and do not act to brace the rim to the hub and could not do so unless the rim stretched gradually. The only time the arms can have a chance to hold back on the rim is after the rim has broken with a shock and started to move outward. It is then too late; the rim parts from the arms with disastrous results.

If the usual design of balance-wheel joint is examined the links will be found to be designed to equal in strength the solid part of the rim. This leaves the weakest part of the wheel at the point where the link is let in, reducing the area of the casting which breaks with a shock before the arms can be of use.

Now if these links were reduced in area to a point where they would stretch when the speed becomes dangerous, the load on the rim structure could be gradually transferred to the arms with the result that the wheel would stand speed enough to confound some of the so-called experts.

The stretching link might be employed with excellent results in the design of hydraulic presses and like machinery, and would save many costly breaks.

The wheel that I think would stand the most rim speed was designed and molded by a colored molder in Covington, Ky. The wheel is 10 feet in diameter and located in a foundry plant where the previous wheel had failed from "a combination of bad shrinkage and bad speed," as the foreman said.

The new wheel was made as follows: Five-foot lengths of 5-inch shafting were upset on the end to a good head and ten of them laid in the mold radially so that their ends would be cast in the rim. The hub was molded up but the rim was poured first and left till it was cool. Then the hub was cast with the inner ends of the wrought-iron spokes embedded therein. When the hub cooled the resultant shrinkage loaded those arms to the limit—and then some.

E. E. CLOCK.

New York, N. Y.

Getting Results

Some time ago I rebored the cylinder of a 20x36-inch Corliss engine, and in assembling I noticed and called the chief's attention to the fact that the springs on the ring, which was five-eighths inch wide and made in four sections with a spring riveted on each section, were entirely too strong for such a narrow ring. As the rings came from the engine builder the chief thought that they must be right and insisted on putting them in. After coating the cylinder well with graphite and taking every possible precaution, the engine was started and run for a couple of hours empty; the load—about 500 kilowatts—was then thrown on and within twenty minutes the piston started to cut the cylinder and the engine soon died an unnatural death.

I stripped her again and proposed reboring as the cylinder and bull ring were badly cut. This would have exposed the blunder and placed the blame on my superior's head, so he instructed me to pull out of the trouble by hook or crook. With a piece of a broken emery wheel I ground the cylinder in, which was no easy task, and applied the same medicine to the bull ring. The question then was, Would she cut as fast again and what means did we have of detecting any cutting? Putting lighter springs on the steam ring, I assembled the engine again; then leaving the cylinder head off and disconnecting the head-end exhaust valve, and strapping it closed and blocking up the pick-up so that the head-end admission valve would not open, I put the engine on front center and started, against the advice of the chief. Not a great quantity of steam leaked past the piston and I could watch its action in the cylinder to perfection. After running for an hour, I threw about two-thirds of the load onto the engine and carried it until fully satisfied that she was O. K.; then putting the cylinder head on and connecting up the valves, went ahead with all sails set.

WILLIAM PRICE.

Philadelphia, Penn.

Care of Turbine Auxiliaries

The engineer who has never had any experience with vertical turbines probably has no idea of the care and attention required by the auxiliaries.

Let us first consider the step-bearing pumps, I say pumps because step-bearing pumps are seldom installed singly.

The oil pressure in the bearing is maintained by means of the accumulator, and in some cases amounts to as high as 500 pounds per square inch. The accumulator is a heavy casting fitted with a tail pipe and the whole moves up and down in a hollow stem. The discharge from the pump is piped to the accumulator stem, branch pipes are taken from the discharge to the step bearings, pressure gage, shaft bearings, and to operate the turbine valves if the machine is so designed. By a series of cables attached to spools on the throttle-valve stems and thence to some convenient place on the accumulator the steam is shut off automatically when the accumulator has reached a certain hight; but as the oil is flowing, the accumulator will drop down a little until the throttle valves are opened by a counterweight on the valve-stem spools and consequently the accumulator is pushed up again. These cables should be inspected every day and kept dry, for a lot of trouble will follow if one of them breaks.

If the pumps are outside packed the glands must not be neglected. They

must be screwed up square and not extra tight, as it will make the pump jerk through the stroke. When the plunger is drawing in oil the pressure is off the packing on that end; the packing nuts may then be moved quite easily and may work off if not attended to. Another thing to be attended to is the baffler through which the oil has to pass on its way to the step bearing. In this baffle is a screen to filter the oil, and this has to be taken out frequently to be cleaned. Care must be taken when replacing the screen to have the cover-plate gasket, which is usually of lead or copper, fit snugly upon its seat and the cap screwed on tightly, as the safety of the machine depends largely on this part.

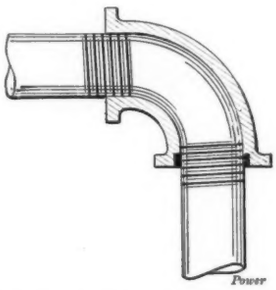
D. W. JUNIOR.

Attleboro, Mass.

The Use of Metal Cement

Some time ago there occurred a bad leak in a 6-inch nipple where it screws into a flange on the boiler. The next time the boiler was washed the nipple was taken out and it was found that the threads on it were in bad shape. As I did not have another nipple in stock, I decided to use some metal cement. When steam was again turned on, the joint was found to be perfectly tight and it has remained so ever since.

I have found that when the threaded joints in old piping start to leak and no amount of screwing up will stop the leak, if it is possible to disconnect the joint



JOINT CALKED WITH METAL CEMENT

and cover the threads with metal cement, the joint will give no further trouble for a long time.

Another case which was successfully cured was that of a 4½-inch pipe leaking badly at the joint where it was screwed into an ell. It would have been quite a job to take the joint apart, so I decided to make a repair in the following way: The steam was shut off Saturday night so that the pipe would be cool the next morning. Then with a small chisel a groove was cut in the ell next to the threads on the pipe, as shown in the figure. Then a quantity of elastic metal cement was mixed to a stiff paste and forced into the groove. When the cement started to harden it was pounded into the groove with a hammer and piece of hard wood. When steam was turned into the pipe on Monday, no sign of any leak could be detected.

H. JAHNKE.

Milwaukee, Wis.

Economy in the Use of Oil

On taking charge of a certain lighting plant, I set about trying to cut down operating expenses in every legitimate way possible. The use of oil on the engines soon received my attention. A wringer was secured with which the engineers could wring the oil from the waste used in wiping up about the engines. Various guards were provided to catch the oil thrown off by the machinery. A drain pipe leading from one of the engines to the sewer was found to be carrying off considerable oil and an oil trap was put in to catch this oil which after being passed through the filter was used again; this saved about two quarts of oil a day. A similar trap was put on the drain of the oil extractor on the exhaust-steam feed-water heater; this recovered over a pint of cylinder oil a day, which likewise was passed through the filter and mixed with the engine oil. Both bearings on one engine and one on another were found to be running very warm. On investigation, it was discovered that the oil grooves were all stopped up; proper oil grooves were cut and all three bearings ran much cooler.

After making all of these changes I found that my monthly oil reports showed that I was still using more oil than my predecessor did. I preached oil economy to the engineers, one of whom had worked over a year under the former manager and should have known how the oil was then used. All the preaching was to no purpose, the high consumption of oil continued. After six months word came to me from the head office, that I had used a great deal more oil during the six months than the former manager had used in nine. This was hard for me to believe, knowing what had been done to save oil, but a search of the records convinced me that it was true. But I could not find the leak. To add to my distress, a letter from the chief engineer of the system stated that I ought to be able to run on fourteen gallons of engine oil a month while the consumption sometimes ran double that.

It is a long lane that has no turning; this lane finally turned. A new man was taken on as night engineer and the consumption of oil dropped. He did not let it drip so fast on the bearings and he showed the other engineers that they did not need to let it drip so fast. As there was not so much surplus oil on the moving parts much less was thrown off and wasted. The bearings ran as cool as ever and there was not the least trouble anywhere because of the reduction in oil.

From this experience the writer has learned that the surest way to reduce the amount of oil used, is to reduce it, and that it is an engineer's duty to determine how little oil his engines require.

The consumption of oil per month dropped from twenty-six to twenty-eight gallons per month to six or eight.

Engineers are prone to say that one must use plenty of oil and that they will not be stinted on oil and at the same time be held responsible for the machinery's safe running. This is all right, but it is their duty to make sure that they are not wasting the oil as the engineers in this instance were doing.

G. MILLER.

Denver, Colo.

Engine Specifications

Our firm recently placed an order for a cross-compound engine. The specification called for an engine to be direct connected to a 500-kilowatt generator, to operate condensing at 100 revolutions per minute under 150 pounds pressure at the throttle and to develop 750 horsepower.

It was surprising to see the difference in engine sizes specified by reputable builders to meet these requirements. Shafts varied from 18 to 10 inches in diameter; main bearings from 10x18 to 18x26 inches; crank pins from 8x7½ to 5x6 inches; steam and exhaust pipes varied 2 inches, and flywheels ranged from 50,000 to 30,000 pounds. Crosshead pins and piston rods varied about in proportion. Now it is evident that some of these builders were way off. If the lighter engines were suitable for the duty, the heavier ones indicated a great waste of material which is hardly probable in these days of sharp competition. If the heavier engines were of the proper design for the service, what show does the honest engine builder who puts the proper amount and quality of material into his engine stand in competition with the other fellow who cuts everywhere he can?

It seems to me that engine builders should get together and standardize their engines. Why not assign a certain weight of flywheel per 100-kilowatt generator capacity and design other parts of the engine in proportion? This would eliminate the confusion to the uninitiated buyer and give the builders an equal chance for the business. One reputable builder figured for our requirements an engine with 12-inch shaft, 10x18-inch main bearings, 8x7½-inch crank pins and a 30,000-pound flywheel. Other proportions were equally ridiculous.

H. R. ROCKWELL.

Mt. Vernon, Ill.

Remarkable Reflection

The accompanying photograph of the main generating plant of the Pacific Light and Power Company, at Redondo, Cal., is an illustration of a remarkable case of reflection.

The view was taken in the afternoon when the sun was to the west of the plant and a perfect reflection was given back by a salt lake just east of the station.

The view shows the south and east faces of the engine room. The lower

PACIFIC LIGHT AND POWER COMPANY'S PLANT AT REDONDO, CAL.

building at the back is the boiler room. The big tank at the right is part of the water-softening system.

The excessive smoke is caused by the start of the evening peak load.

The readers of POWER have heard so much about this station, I thought the photograph would be interesting to them.

The engine and boiler rooms are built of reinforced concrete.

J. W. HAUGHTON.

Redondo, Cal.

Starting a Water-works Pump

Last fall I visited a pumping plant. On entering the engine room I neglected to mention that I was an engineer, intending to do so later; but as the minutes slipped by I realized that my chances of saying anything were small for the engineer in charge was an exceptionally good talker and it was almost impossible to get a word in edgewise. As the engineer warmed up to his subject, the fair-sized pumping unit before us, I began to think we were in the presence of a wonderful machine and continued to think so after arriving home where I had an opportunity to do a little reckoning based on figures given to me by the engineer. I found that this engine, of 8 million gallons capacity, was doing better than the 170-million foot-pound duty obtained from very large pumping engines.

I had never seen a pumping engine of this type before and was much surprised to hear the engineer tell of the great skill required in starting one. He claimed, if I remember correctly, that should anything happen to him, it would be necessary, should the engine be stopped at the time, to let it lie idle until a man from the builder's works could arrive or until an engineer with previous experience on this particular type could be procured.

"In starting this engine," said the engineer, "you would naturally think the first thing to be done would be to open the throttle, would you not?" I told him I would.

"Why, if you did that, you would 'stave' the machine all to pieces," he exclaimed.

The engine in question was a triple-expansion Worthington pumping engine with high-duty attachment and no flywheel. Compensating cylinders were fitted to the piston rods which absorbed energy during the early part of the stroke and gave it back during the latter part. The engineer's claim was that should steam be turned into the cylinders before other necessary requirements were complied with (of which he made no further mention), the cylinder heads would immediately be blown out. This was quite startling news to me and a few days later I wrote to the manufacturers asking if they would kindly send directions for starting this type of engine. They replied that they did not have any printed matter on the subject but if I would call at the city pumping station, at Fall River, their expert who was there engaged in erecting a 10 million-gallon pump, would explain the matter fully. I was very sorry I was not able to take advantage of this opportunity and am still in the dark about the method of starting a pump fitted with these compensating cylinders.

Can any reader of POWER enlighten me?

L. C. TUCKER.

Newburyport, Mass.

Location of Lubricator

I have often noticed that one man will place a lubricator on one side of a throttling governor while another will place it upon the opposite side. As in everything else, there is one best way, and I decided to discover which it was. I had, among other engines, one which ran a ventilating fan. To the outlet of this fan I attached a recording-pressure gage. I had the engine equipped with two lubricators, one on each side of the governor.

I ran the test by allowing one lubricator to work for six hours and then shutting it off, and ran the other for six hours. The experiment was conducted on idle days so that I might have, as near as possible, the same condition all the time. I did not draw my conclusions from the result of one day's run but ran six tests on as many different days.

I found that in each case the line on the chart of the recording indicator was more even when the lubricator on the side of the governor away from the engine was in use. From the results I concluded that this was the proper location for the lubricator. The reason is that I think the governor works better with this arrangement for the spindle, is better oiled and hence allows a freer and quicker adjustment of the throttle to the varying conditions due to changing load.

CLIFFORD B. LANGSHOTH.

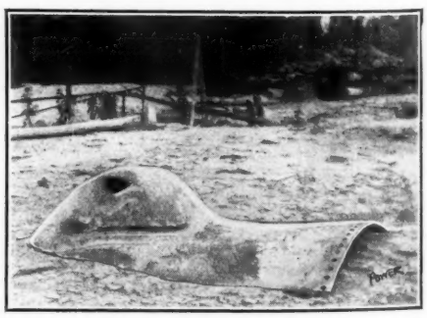
Lebanon, Penn.

Badly Bagged Boiler

The accompanying halftone shows a boiler that I judge was very badly bagged. The accident occurred on September 3, 1909.

Would like to have the opinion of other engineers on why did the bag extend down so far.

The boiler was supplied with water



WHY DID BAG EXTEND DOWN SO FAR?

through the blowoff pipe. The water was taken from a dug well and was very sandy. The boiler was washed about every 30 days but never blown down. The steam pressure at the time of the accident was 40 pounds, gage.

J. A. SUESS.

Winnfield, La.

SUBJECTS *under* DISCUSSION

COMMENT, CRITICISM, *and* DEBATE *upon various* ARTICLES, LETTERS *and* EDITORIALS *which have* APPEARED *in* PREVIOUS ISSUES

Centrifugal Pumps

The article entitled "The Centrifugal Wet Vacuum Pump," which appeared in the January 4 issue, is of special interest to me. I agree with Mr. Calloway that there is a lack of reliable data on the operation of this class of pump. I would like to submit for criticism the results of a pair of tests I helped to conduct on a double, direct-connected, volute pump, having 2-inch suction and 1½-inch discharge pipes. The pump was connected to a 7½-horsepower motor and ran at a speed of 1500 revolutions per minute. The arrangement for conducting the first test is shown in Fig. 1. The water came to the pump under a 3-foot head and was pumped back into the tank. The pressure gage on the discharge pipe registered 30 pounds and the water meter indicated a discharge of 112 gallons per minute for each unit of the double pump. The jet box contained 24 one-quarter inch jet pipes.

In the second test, instead of using the water meter, a hose was attached to one of the jets and the water therefrom run into a pail and measured. Our results showed 120 gallons per minute as the output for each unit. It will be noticed that the pressure gage in the second test was located at the end of the jet box. We found that the pressure here was only 20 pounds. I would like to ask Mr. Calloway, or any other reader who is familiar with centrifugal-pump performances, if the results we obtained are what should be expected. I should also like to have an opinion as to the reliability of the testing rig we have described. It may be possible that 1500 revolutions per minute is too great a speed for this type of pump. I should like to hear expressions of opinion on this point also.

W. C. STEPHENS.

Buffalo, N. Y.

Storing the Energy of Exhaust Steam

In the issue of January 11 we note an article headed "Storing the Energy of Exhaust Steam."

In describing the American regenerator it is stated that, "In entering the lower chamber the exhaust steam operates a vane which in turn controls a valve in the pipe connecting the upper and lower chambers. Thus the amount of water supplied to the outside of the spray pipe is always proportional to the amount of exhaust steam passing through it. In this manner the steam comes in through contact with the water, which as a consequence is heated up to the full temperature of the steam. The momentum of the steam is sufficient to carry the mixture of water and steam up through the eduction pipe into the upper tank, where the mixture is delivered against suitable baffles and separated from the steam. With the arrangement shown in the illustration the coldest water, which is naturally at the bottom of the large tank, is intimately mixed with the exhaust steam and returns to the surface of the water, inducing good circulation, and mixture of water and steam."

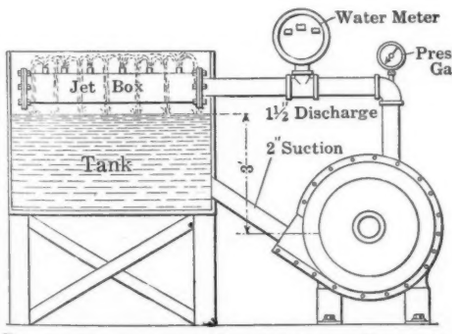


FIG. 1. OUTFIT USED DURING FIRST TESTS

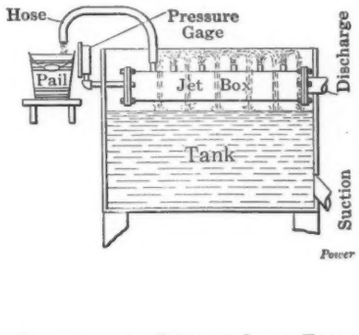


FIG. 2. OUTFIT USED DURING LAST TESTS

The article further on states, "To supply one pound of steam at 15 pounds absolute pressure requires 965.6 heat units, and if the total range in pressure is from 15 to 18 pounds and from 212 to 222.4 degrees in temperature, each pound of water will restore 9.4 B.t.u. To supply 965.6 B.t.u. to evaporate one pound of steam, the tank should hold 103 pounds of water for each pound of steam to be supplied to the turbine during the period of regeneration."

If the 103 pounds of water have been raised to 222.4 degrees, the above statement is obvious; in other words, if all the water is not constantly brought to the temperature of the steam, the storing of heat by the regenerator is not performed, and the regenerator is inefficient.

The fact that in the American regenerator there is an appreciable difference of temperature in the body of water shows that the circulation is not perfect and that all the contained water is not effective.

The description of the apparatus indicates that such must be the case, as the circulation of water is brought about by means of a highly inefficient entraining nozzle working under very adverse conditions, as the entrained element is stationary and the entraining element is at exceedingly high velocity.

Furthermore, the entire mass of water, in average-size installations from 40 to 100 tons, must be raised some 10 or 12 feet by the entraining nozzle in a period of time which, in ordinary practice, ought not to be over two or three minutes.

This necessitates a considerable amount of power, sufficient to make the apparatus commercially impractical.

The absorbing capacity of all types of regenerators must be exceedingly rapid, or else the pressure will rise in the apparatus and steam will be blown off through the relief valve long before the water has reached a temperature corresponding to that of the steam pressure.

The reading of gages placed in the piping leading steam to and from the regenerator, combined with a test showing the heat-storage capacity of the regenerator for a given period, will show all that is necessary to determine the practical value of the apparatus.

In order that any type of regenerator may operate, it is essential that it be a very efficient steam condenser, for it is through the condensation of an excess of steam that the regenerator is capable of acting as such. It is this fact which necessitates a great surface of contact between water and steam.

Steam regenerators have to work with very small differences of temperature, as the allowable range of pressure is exceedingly small; in ordinary practice some three or four pounds.

The process employed by the American regenerator to mix the water and the steam is quite similar to a jet condenser, in which the condensing water is at a

temperature very nearly equal to that of the incoming steam.

The illustration published in POWER of the American regenerator indicates that a relief valve has to control a slide valve, which in turn admits the heat-retaining medium, i.e., the water contained in the upper regenerator into the lower regenerator.

All engineers will agree that a relief valve operating on the exhaust of a reversing engine, such as a mill engine or a hoisting engine, has a pretty severe duty to perform.

To expect such a valve to control the essential feature of an apparatus is perhaps somewhat imprudent.

If the slide valve should stick and remain open, the entire plant might be wrecked, for the lower regenerator would fill with water and when the exhaust of the engine, starting anew, struck the relief valve, the valve would be under water, and the back pressure could rise as high as boiler pressure, and a great disturbance would take place.

In case the slide valve should stick and remain closed, the regenerator would stop acting as such.

When the exhaust steam stops flowing, the slide valve closes and the water contained around the exhaust pipe in the lower regenerator will flow out through the perforations in the pipe. Thus, the regenerator will lose this amount of water every time there is a stoppage of the main engine, or when the exhaust steam is not sufficiently abundant to raise the water to the upper regenerator. This will necessitate the constant attention of the plant operators.

L. BATTU.

New York City.

Writing for Catalogs

I have been in the engineering business for 25 years and during that time, I have bought a good many dollars' worth of engineering books, but think I have received as much benefit from trade catalogs as I have from the books. I have never been able to find an engineering book which fully describes the different appliances manufactured by different companies; appliances that are likely to come under our care at any time.

I like to look over the advertising section of my copy of POWER and I find that I get a lot of benefit by so doing. The companies that get up catalogs are the same that advertise. They would not advertise unless they wanted engineers and firemen to read. Now I don't see why they should not be willing to mail their catalogs to anyone who is interested enough to take the pains to write for them. A mistake is often made by engineers and firemen when writing for catalogs in that they do not explain their position and reasons for wanting the catalog. If explanations were made the companies would be saved the expense of numerous follow-up letters, sent out for the purpose of discovering what prospects there were of getting business.

As a general proposition, I think most companies are glad to send out their catalogs if they know what your position is and why you want them.

E. A. YOUNG.

Isabella, Tenn.

Belt Troubles

In the January 4 issue, Mr. Berkley writes of a trouble similar to one I experienced. When I took charge of a small lighting plant last June, I found a 60-kilowatt, 2200-volt alternator driven by a 9-inch belt. The belt was cut, apparently, from an 18-inch belt and consequently the center of the old belt came at one edge of the new belt. My predecessor evidently had had trouble with the belt because he used a guide made of pipe fittings as shown in Fig. 1. The belt ran very close to the housing of the machine and would rub very hard at times; the guide only made matters worse and opened the belt on one side as shown.

The belt was running with the laps. I turned it inside out and ran it for a while until the belt was straight. I then glued and pegged the edge of the belt and put it on as it was before but could not keep it on. I ran it with the laps, against the laps, right side out and inside out, but to no avail. As soon as the load would lighten, off came the belt. One night I was especially anxious to have the lights remain on when the load dropped off and

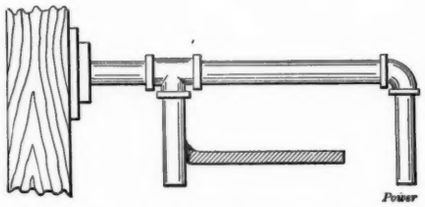


FIG. 1. THE BELT GUIDE

knowing that powdered rosin or belt dressing was of no avail, I dug up an old mill file. When the belt started to "act up" I held the file down on the belt until the flying dirt and leather burned me. The belt stayed on with an occasional coaxing with the file.

I finally got over the trouble by cleaning the belt thoroughly and shifting the center line of the alternator as shown in Fig. 2. The amount of shift must be very slight because the belt tends to crowd to the high side and work off if the angle is too great. I scraped the belt about once a week and applied a little neatsfoot oil after each scraping.

My pulleys are on 25-foot centers, the driving pulley is 5 feet 10 inches in diameter and the driven pulley is 14 inches in diameter, the belt speed 4900 feet per minute.

My experience has been that the cleaner the belt is the less it will slip, and that powdered rosin and belt dressings should be avoided. A little neatsfoot oil applied occasionally will keep the leather soft and pliable and will work the dirt out of the leather.

Mr. Berkley does not give his belt speed, and, therefore, one is unable to judge whether his belt is too small for

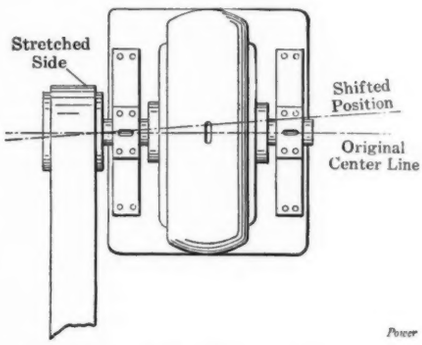


FIG. 2. CENTER LINE OF ALTERNATOR SHIFTED

the load. I use the following approximate formula: A single belt under a working strain of 60 pounds per inch of width, running 550 feet per minute, will transmit one horsepower for every inch of width. The pull, in pounds per inch of width, equals,

$$\frac{H.P. \times 33{,}000 \times \text{width of belt}}{\text{Belt speed in ft. per min.}}$$

For dynamo work, the pull or load per inch of width in single belts should not exceed 40 pounds under a speed of 4000 feet per minute nor 32 pounds under speeds from 4000 to 6000 feet.

G. B. KAMPS.

Zeeland, Mich.

Safety of Manning Boilers

In the issue of January 25 there is an interesting article by C. A. Giles under the caption "Safety of Manning Boilers," which contains one or two errors.

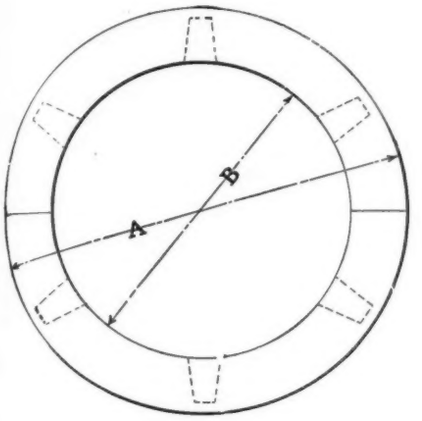
In the first place, there was but one aisle between the tubes, not two at right angles, as Mr. Giles states. In the next place, there was no dirt or scale on the crown sheet. The Merrimac river water is the best I have ever used for boiler-feed purposes, being absolutely free from all lime salts. Had the tube ends been beaded instead of flared, they would have cracked off and the release of pressure would have been much more sudden and a real explosion would have taken place.

CHARLES H. MANNING.

Manchester, N. H.

Trouble with Turbine Pumps

With reference to H. S. Wildermuth's query in the January 11 issue, as to the probable cause of loss of suction in his two-stage turbine pump, while he gives the length of suction piping, he does not say whether this piping is free of air



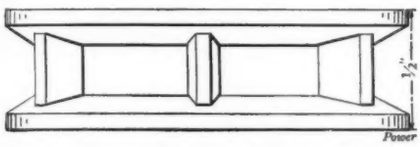


FIG. 1. LANTERN RING MADE IN HALVES

pockets or not. If his suction pipe has the proper lead and all joints are tight, the probable cause of the trouble is in the stuffing boxes.

Mr. Wildermuth states: "The pump worked all right for about two and one-half months when it developed a leak in

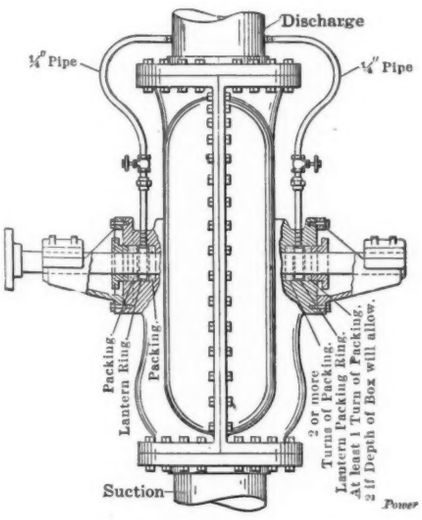


FIG. 2. PACKING AND RINGS ASSEMBLED

the stuffing box which we repacked; then it worked well for a few days more." This goes to show that the leaky stuffing box was the cause of trouble in the first instance, and I believe in the absence of further data, that it is the cause of his present trouble for he says further: "When the pump began working badly again it showed signs of poor suction."

I would suggest that he make a set of brass lantern rings, as shown in Fig. 1. The dimension *A* should be 1/32 inch smaller than the inside diameter of the stuffing box and *B* 1/16 inch larger than the pump shaft. These lantern rings should be fitted on as shown in Fig. 2. Drill and tap the stuffing boxes for ¼-inch pipe, directly over the lantern when in place. Run pipes from the stuffing boxes to the delivery side of the pump or to the delivery pipe, as shown. The pressure from the delivery head will then be applied to the packing and if the packing is not tight, water will leak from the stuffing box around the shaft and thus oppose the tendency for the air to enter.

Arrange the position of the lantern rings so as to obtain at least two or three rings of packing on the pump side. One ring on the gland side will answer, if the box is too shallow, but two rings here are preferable also.

While the idea is not new, in fact it is applied to a great many centrifugal pumps with a large or medium suction head, I have noted that very few centrifugal or turbine pumps with small suction head are so fitted; but if they were, a big source of trouble would be avoided.

O. Z. HOWARD.

Annapolis, Md.

In reply to H. S. Wildermuth in the January 11 number I will say that I have in my charge a three-stage turbine pump running at 1700 revolutions per minute. It operates against a 9-foot lift and the discharge pipe is 5800 feet long. The pressure is 135 pounds. The suction pipe is 6 inches and the discharge 3 inches, increasing to 6. The first trouble we had was that the foot valve hung up and let water back through pump, carrying with it trash left in the pipe during erection, which filled the propellers. We took the pump apart and cleaned the propellers. It has leaked around the stuffing box ever since, and when it gets out of order, I generally trace the trouble to that source. We run the pump only at night; no one watches it; it is started from the power house about two miles away; it gets a visit about twice a week; the packing is renewed every two weeks; by this means we keep down the amount of trouble it gives. We have a foot valve in the suction and a check valve in the discharge line with a 1-inch bypass which is kept open all the time so that we can tell when there are any breaks due to water leakage. I seal all joints with white lead when I have trouble with the pump, for I have found that if there is any air leakage whatever, the pump will not work. I find too that a turbine pump will not pick up its water without priming it.

W. M. LAY.

Marvel, Ala.

After building turbine pumps for three years I find it is very necessary to have a strainer and a foot valve on the suction pipe and to have the suction pipe as short as possible.

Place a gate valve right on to the discharge flange of the pump and every time the pump is stopped, close this valve. When starting up, open the air cocks on the top of each stage to let the air out until they show good water pressure and then close them. If the motor is up to speed and your pressure on the pump registers full head, open the gate valve slowly until you have it wide open. If these instructions are followed, the pump is sure to work, if it is in good condition. But if you have a leak in the suction pipe or the bearings or if a blowhole has developed, which sometimes happens around the binding-bolt bosses, or if you have been drawing sand and grit and have cut out the water space around the impeller, the pressure will be reduced.

SILAS VANDETTE.

Montreal, Que.

Why a Cylinder Once Oiled Needs Oil

In a recent communication to POWER, W. E. Crane mentioned an engine which worked nicely without oil but when oil had been once used became very sensitive, for the reason, as he said, that the oil had produced a fine surface. In response to an inquiry as to why a finer, smoother surface should cut up quicker than a coarser, rougher one, Mr. Crane says:

I don't know. I have tried to think out a suitable reason but have never found one satisfactory and can only be guided by observation.

A surface that has been formed by two surfaces sliding on each other appears to get along all right, but a surface that has been formed by the interposition of oil is different, as the surfaces have been kept apart by oil globules and have a surface caused by rolling contact and when these rolls are taken out and the surfaces brought together the abrasion appears to pick up the surface and the small particles will tear a streak the whole length.

I would like to know why.

While I was noticing some of the antics or idiosyncracies, I read a story by a man who said that when he bought a nice watch he took it to a reliable jeweler whom he knew to be honest and had him wipe the oil all off and leave it entirely free from oil and then he never had any trouble and it would run for years without trouble or expense.

At the time I had a high-grade Elgin watch that I thought I must have cleaned and oiled at least once per year, but some way it appeared to have gotten out of order and was not the good time-

keeper it was when first purchased. I had become pretty good friends with the inventor of the Waterbury and he said he could put it in good shape and I asked him to leave it entirely free from oil. This watch became a first-class timekeeper for many years.

Watch pinions moving in jewels do not appear to be troubled with abrasion because of the small friction. In this case I think some of the better jewels had been removed and cheaper ones substituted.

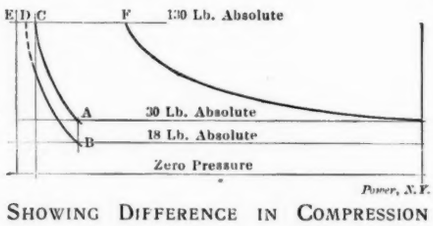
Later I was presented with a new-style Waterbury, now the New England Watch Company; I had the oil all cleaned off and have carried it 14 years without cleaning or oiling.

W. E. CRANE.

Duluth, Minn.

Receiver Pressure

E. H. Lockwood on page 1032 of the December 21 issue attempts to explain that lowering the receiver pressure of a compound engine will cause it to do more work but use more steam. As corollary to this statement would it not be logical to presume that the engine would do the same work, at the same rate of speed with an equal measure of steam after lowering the receiver pressure? What is desired to be known is, will it consume more, or less steam, when doing the same work at the lower pressure; and this Mr. Lockwood failed to prove. Accepting the figures presented in the first part of his article as applying to a 12x36-inch engine, and neglecting cylinder condensation, how would the result stand supposing the stroke of the engine was changed to 48 inches, the cutoff remaining the same as at present, thus giving a cylinder capable of lowering the terminal pressure, and utilizing



SHOWING DIFFERENCE IN COMPRESSION CURVES

a greater number of expansions? Would not the result of his deduction calculated in the same manner prove that this engine was wasteful? Cylinder condensation aside, which of the two engines would he buy if he were offered both at the same price? Figures carry but little conviction to the practical mind, but in the diagram there is something tangible. Admitting that the line *D C* represents the difference in the steam consumption between the two diagrams, I fail to see why this shows 9 per cent. more steam used in one case than the other. He admits in the reading matter that the engine speeds up and does more work with the lower receiver pressure. Why does he not allow for this in the diagram? Can he prove that the extra speed times the extra work done does not represent a factor greater than could be obtained from the 9 per cent. loss? Supposing that the work done was the same in both cases, has he in any way showed that the admittedly earlier cutoff did not equal or supersede that 9 per cent. loss and show a balance in steam admitted to the high-pressure cylinder in favor of the lower receiver pressure? It is unfair to take the steam line *E F* in both cases, especially after admitting that the engine runs faster in one case than in the other. It will not be denied that compression represents work done by energy stored in the flywheel, and that more of this energy is demanded to compress the steam represented in the reproduced diagram from *B* to *D* than from *A* to *C*, though the power given back to us is the same in both cases, as the steam expands to *G* only. Now continue the compression curve *C A* to *H*; it will be apparent that the engine has done more work in compression, but the line *D C* representing the 9 per cent. loss has disappeared. The area of the high-pressure diagram has been materially decreased but it is evident that as the same amount of work was performed as before, and as the receiver pressure has not been changed, there must be the same area of diagram as before to complete the formula

$$\frac{PLAN}{33{,}000} = \textit{horsepower.}$$

It is absurd to evade the fact that, assuming theoretical conditions, the space *D C* has simply moved from the *C* end of the diagram to the *F* end. This is not an argument against high receiver pressure. It depends on the cylinder ratios whether a high or low receiver pressure is the more economical. If the area of the low-pressure piston is such that the extra power developed by raising the receiver pressure, will outbalance the loss caused by back pressure in the high-pressure cylinder, then it is good policy to raise the receiver pressure, and if this is not the case, it must be good policy to lower it.

H. HUGHES.

Roxbury, Mass.

In the discussions on receiver pressure in the November 16 and December 21 issues, the question seems to be settled to some extent by the arguments of Mr. Lockwood showing the points of agreement between practical observations and theory. I have observed a few good-sized compound engines, the operation of which tended to show that the best results are obtained when the pressures are in the inverse ratio to the areas of the cylinders. This brings about an equal temperature range and an equal amount of work in each cylinder, and the indicator diagram will show but a slight drop in the high-pressure cylinder at the end of the stroke. The rule for adjusting the receiver pressure may be formulated as follows:

Divide the total effective pressure of the steam by the sum of the numbers representing the ratio of the cylinder areas; the quotient will give the effective pressure to be left for the receiver.

For example, let the pressure in the steam pipe be 132 pounds absolute; exhaust 2 pounds absolute; diameter of high-pressure cylinder 12 inches; low-pressure cylinder 24 inches. The effective pressure, or the total range in this case is

$$132 - 2 = 130 \textit{ pounds.}$$

The ratio of cylinder areas is 12^2 to 24^2, or 1 to 4. Divide 130 by (1 plus 4) and the quotient 26 is the proper effective receiver pressure, or a total of

$$26 + 2 = 28$$

pounds absolute. This rule has the advantage of being convenient.

J. M. SPITZGLASS.

Chicago, Ill.

Safety Devices

In looking over some of last year's numbers of POWER, I noticed an editorial on the flywheel as an element of danger, which states there are 30 per cent. more flywheel explosions than boiler explosions.

In almost every issue there are very interesting descriptions of flywheel or boiler explosions, telling of the terrible results of such accidents and the loss of life which occurs in many instances.

The loss of flywheels in many instances is caused by the failure of some automatic device or speed-limit system or by the failure of some part of the governor or engine itself, not to speak of other things liable to happen to an engine which would cause it to race or speed up to the danger point.

As a high-speed engine or any other, for that matter, is absolutely at the mercy of its governor, it strikes me that some positive and safe means should be provided besides the throttle to shut off the steam supply instantly in case the engine becomes disabled or starts to race and that not too much dependence should be placed on any automatic device which may fail or become inoperative at the critical moment.

It should be unlawful not to equip all steam engines and high-pressure boilers with the latest and most positive safety devices obtainable. That a law to this effect is necessary is very apparent; it should have the indorsement of every engineer as it would be instrumental in saving human life.

According to the statistics of the casualty companies this matter is of the utmost importance to all engineers as it

is claimed that there are at least 12 flywheel explosions in the United States every month.

I am unable to understand why engineers cannot see value in any device which tends to make their calling less dangerous.

W. D. RANNEY.

Columbus, Ohio.

Bettering the Lot of Engineers

I have read a number of articles in POWER on the topics of twelve-hour shifts and general conditions in engine and boiler rooms. I agree that conditions are not what they should be. Many employers think that as changes cost money and hence cut profits, why make changes beneficial only to the engineer? True, it is hard on the men who do the work, but, Mr. Engineer, you must bear in mind that you are only a cog in a great industrial wheel, a part of the machine, and your employer buys your labor and brain power in much the same way that he does a pump or any machine; he buys you in the open market, as cheap as he can, works you to the limit and when you are of no further use to him, dumps you onto the scrap pile, worn out.

Of course, there are exceptions to the rule, but in discussing a broad question we must base our arguments on the average, not the individual case. I do not blame the employers, for most of us would do the same thing if positions were reversed. Why? Because if we did not, our competitors would put us out of business.

The employer because of his ownership of the machinery can dictate wages, hours of labor, etc.; he owns your job. But, you say, I will not work unless I get my price. Very well, there are others on the waiting list who will be glad to accept; you may go elsewhere, but you have to seek a master just the same.

What regulates wages? The lowest price the hungriest man out of work will accept. True, there are some engineers who set their price, but they are more than engineers. They are generally good advertisers and know something of salesmanship and how to market their ability.

What can the average engineer do to better his condition? Let us learn our lesson from the captains of industry, our employers. A few years ago they were fighting each other for markets, but they have learned their lesson; now, they are organizing trusts and combines, in plain words; forming unions that they may control markets and prevent competition on one hand and reduce the cost of manufacturing on the other. They do this because it pays; it is the most economical way to do business.

Now the point I wish to make is this: If it pays the employers to organize, it will pay you; if it helps them to control the market for their products, it will help you in the same way; if by organizing they can hold down the price they pay you for labor, then by the same token, it will help you to get a higher price for your labor.

True, you cannot go on strike and fight money with an empty stomach, but much can be done without resorting to the strike. If you are organized you can work for national license and boiler-inspection laws, and other legislation along the same line. Fifty thousand engineers, united, could bring considerable pressure to bear on legislators. Education should be a large part of the program of the organization.

When you confer with your employers select men who know something of human nature and can use that knowledge to advantage, men who can show the employers that it would pay to make conditions better.

C. C. HARRIS.

Springfield, Mass.

Metallic versus Carbon Packing

In a recent issue of POWER I read description of a metallic packing for Curtis turbines.

Among other advantages claimed for this packing over the carbon packing now used is the one that it eliminates the dust from the disintegrated carbon, which is forced into the dry-vacuum pump and causes a gumming of the valves.

The question is, does the carbon dust cause the gumming, or is it the result of the burning of the lubricating oil used in the valves? One thing is certain, the valves do gum.

We have two 2000-kilowatt Curtis turbines with Worthington condensers and hotwell and dry-vacuum pumps. With the air end of the vacuum pump clean, we can maintain a vacuum of from 29 to 29½ inches. After running without cleaning for three or four months the vacuum will drop back to 27½ or 28 inches. Upon opening the pump for cleaning, we find a coating of what we call burnt oil about ⅛ to ¼ inch thick all over the valves and the inside of the valve chest. The coating is partly in the form of a gum, but most of it is about as solid as boiler scale. Between the slide valves and their seats is a thin, glassy scale which prevents the valves from seating. The poppet valves get stuck tight and refuse to work. The ports under them and the spiral springs in them will be filled with scale. The cylinder ports will be found to be from 25 to 50 per cent. closed with a very hard scale.

To clean the pump properly is a fair day's work for two men; the cylinder ports are especially hard to dig out.

In a four-months run the carbon-packing rings in the turbine might wear one-hundredth of an inch, on a 10-inch ring. The dry-vacuum pump will contain about three pails or 36 quarts of gum, scale or whatever you may call it. Now, how could the little carbon which wears off the packing rings make so much gum in the pump, even if none of the dust went out through the hotwell?

We believe the trouble is caused by the oil. Since I have been here, we have tried two different kinds. One was heavy and very much like cylinder oil. The other, which we are using now, is light, like the oil used in the air cylinder of air compressors.

After cleaning the pump, considerable Albany grease is put on the slide valves.

I would like to hear from turbine engineers on this and other troubles, of which there are many, in turbo-electric plants.

W. E. BERTRAND.

Upper Darby, Penn.

Cutting Oil-Cup Glasses

C. D. C., in the February 8 issue, wants to know of a suitable way of cutting oil-cup glasses.

I have been told that, if a glass is bound tightly with a cotton string at the proper place and if the string is, after that part encircling the glass is burned, the glass can be broken easily.

While I have never tried this myself it sounds practicable and I would like very much to learn whether others have tried it and with what success.

CHARLES F. CHASE.

New York, N. Y.

Load Factor

The discussion in POWER on the subject of "Load Factor" has led me to say a few words.

As stated in the editorial, the term, "load factor" means the ratio between the actual output of the plant and the full-load capacity. The term "load factor" as defined by Mr. Neilson as the English practice, namely, the ratio of the actual output of the plant to the maximum load carried, would seem to be well expressed by the term "capacity factor."

To estimate the load factor on the basis of the maximum load ever carried by the plant is not a fair way. However, if an expression for this relation is wished it seems that the term "capacity factor" expresses all that could be desired. The term "plant-load factor" as stated by Mr. Neilson, does not have enough distinction from the term "load factor." I do not say that this term is out of place or the one proposed above is in common use, but merely state that logically it seems to fit the case.

G. A. GLICK.

Madison, Wis.

Flue Gas Analysis and Boiler Firing

Lectures on Combustion While a Test Is in Progress. Results Recorded by Apparatus upon the Stage in View of the Audience

The engineers of Boston and vicinity to the number of upward of five hundred assembled on Tuesday evening, February 8, at Franklin Union hall, to witness a demonstration of the operation of CO_2 recording and flue-gas analysis apparatus and to listen to addresses upon the subject of combustion. The boilers of the Franklin Union are located directly under the stage of the large auditorium. The stage was filled with apparatus of the Sarco, Uehling and Orsat types, which were connected to the boilers below, and observations were made of the percentage of CO_2, flue temperature, and of the draft in the flues and in the furnace every 15 minutes and plotted in different-colored crayons upon a large blackboard in view of the audience.

The Franklin Union

Edward H. Kearney commenced the speaking by saying a few words in regard to the steam course conducted by the Franklin Union, an institution endowed by Benjamin Franklin and Andrew Carnegie for the educational benefit of the workingman. They have five classes in steam engineering, a fireman's class, also a gas- and gasolene-engine course. These courses are all taught by practical engineers and professors with laboratory work and lectures and the fee for attendance is $6 per term, consisting of 72 nights of two hours each, so that the tuition costs about 8 cents per hour to the pupils, but every pupil turned out means an outlay of about $100 to the Union.

D. T. Randall, formerly of the United States Geological Survey, Fuel Testing Department, but now connected with the laboratories of A. D. Little, spoke upon

Conditions Which May Influence the Efficiency of Boiler Plants

In the average plant the expense for coal is from 30 to 50 per cent. of the entire cost of generating power. It is now pretty generally accepted that coals of the same general character and size are of value in proportion to their British thermal units.

It often happens that coals of an entirely different character are mined within a few miles of each other. For example, the coals mined in the Pittsburg district contain approximately 33 per cent. of volatile matter, and it is possible to burn from 60 to 65 pounds per square foot of grate, with a draft of approximately one-half inch of water.

The coal mined only a few miles east in the vicinity of Johnstown contains only about 16 per cent. of volatile matter, and with the same equipment and draft only about 40 pounds can be burned per square foot of grate surface.

It is evident that a different design of furnace is required for highly volatile coals, but it is believed that when the furnace is properly designed such coals may be burned with high efficiency. Experiments on different types of furnaces conducted by the Government's fuel-testing plant have shown that furnaces surrounded with water-cooled surfaces and having small combustion chambers are from 10 to 12 per cent. less efficient with coals which are high in volatile matter than when burning coke or anthracite coal. Within reasonable limits the percentage of ash has very little influence upon the efficiency with which the coal is burned, but it has an influence upon the capacity with which the equipment may be operated.

The following table suggesting the disposition of the heat evolved by the fuel in a well-conducted boiler plant was submitted.

	Per Cent.
Heat absorbed by the boiler	70.00
Heat lost in evaporation of moisture in coal	0.20
Heat lost due to burning hydrogen	3.50
Heat lost in escaping gases	14.00
Heat lost due to incomplete combustion	1.30
Heat lost in carbon to ashpit	3.00
Heat lost due to radiation and other losses	8.00
Total	100.00

Excessive draft introduces too much air through the fire and also causes serious leakage through the entire furnace and boiler setting. In this connection the damper regulator, if one is installed, deserves much more careful attention than is usually given, for the reason that a damper regulator which works improperly may easily waste a large percentage of the fuel by alternately furnishing too much air when the steam pressure drops and not enough when the pressure is normal.

Air Supply and Regulation in Boiler Furnaces

E. G. Bailey, mechanical engineer of the Fuel Testing Company of Boston, said that two things are of primary importance in operating a boiler plant—capacity and economy. Nearly every boiler plant is supplying power for a purpose which would entail heavy expense if it were interrupted; therefore, capacity takes precedence over everything else. However, it should be necessary to sacrifice economy for capacity only at exceptional times, and a plant should be operated at its maximum efficiency and still be capable of developing all the required power. In order to secure such conditions the supply and regulation of air for the combustion of coal are of more importance than all other factors combined.

With a level fuel bed and a constant draft pressure the rate of combustion can be varied by changing the thickness of the fuel bed. The rate of combustion increases with the thickness of the fuel bed up to a certain point, beyond which a thicker fire causes a decrease in the rate of combustion. The quantity of air passing through the fuel bed per hour per pound of coal burned continually decreases as the fuel is thickened, and the most economical amount is obtained near the point of maximum capacity with a constant draft. The thickness of fuel bed necessary to secure maximum capacity and efficiency depends upon the nature of the fuel and the intensity of the draft. Sometimes it is 4 inches while under other conditions it may be 14 or possibly more in exceptional cases. The more nearly level a fuel bed is maintained, the thinner it should be, other things being equal.

It does not require skill to shovel coal into a furnace, but skill is required in distributing the air and mixing it with the fuel. A fireman can control the steam pressure entirely by the condition of the fuel bed, and many of them do it. It is a very wasteful method, for it is often necessary to carry a very thin, or else a thick choked fire in order to greatly reduce the rate of combustion, and either condition is wasteful of fuel, one by excess of air and the other by unburned gases. The function of a damper regulator is sometimes misunderstood, and a uniform steam-pressure curve is sought rather than a draft proportional to the load. Such results are obtained with a very sensitive regulator, when a very slight change in steam pressure will cause the damper to change from one extreme position to the other, and very great changes in the draft pressure follow only very trivial changes in the steam pressure and small variations in the load. Data recently obtained illustrate this point very clearly. The total load on the engine varied 28 per cent. of the average in an hour, while the steam pressure varied only three pounds or 2 per cent. in the same time. The draft varied 175 per cent. of its hourly average, and the damper reversed its direction of motion 32 times in the hour, but

did not reach an extreme position but three times. If the fire is right for the average draft, it is too thick when the damper is nearly closed and too thin when wider opened. The loss due to air excess alone varied from 3 per cent. with the damper nearly closed to 17 per cent. with it open. It is impossible to change the thickness of the fire to meet such variations in draft, nor would there be need for such change in the condition of the fuel bed if the draft had varied proportionately to the load instead of over six times as much. It would be more economical to strive for a smoother draft-pressure curve and allow more variation in the steam pressure if necessary. The equivalent net area for the flow of air through a fuel bed may not be more than 5 per cent. of the grate surface covered; hence it does not take many cracks or openings in the settings to allow leakage to amount to a considerable percentage of that passing through the grate. It frequently amounts to 25 per cent. and sometimes exceeds 100 per cent.; in other words, as much or more air may be going through the boiler setting as there is coming through the grate. Excessive draft pressure causes more waste of fuel in this country today than does insufficient draft.

Smokeless Combustion

was considered by John S. Schumaker, of Boston. It has been the general contention that the economical use of fuel is a question of fireman, and that smokeless combustion is a question of special furnace design. How deeply the conviction is fixed that with the fireman rests the solution of the economic use of fuel is evidenced by the recent report of the fuel committee of the Boston Chamber of Commerce, which recommends the establishment of some form of training school for firemen, so that they might become "skilful firemen," and advocates some form of agreement among employers whereby they shall give preference to these specially trained men. The idea is not undesirable but it falls far short of meeting the needs of the situation.

The economic use and smokeless combustion of fuel rest entirely upon the conditions under which the combustion is carried on, and the average fireman's lack of "skill," so called, does not affect these conditions in any measurable degree. His wilful neglect may defeat the attempt at economic use and smokeless combustion of fuel, but his lack of so-called "skill as a fireman," never!

Smokeless combustion is dependent only upon a sufficient supply of properly distributed air and a certain relative thickness of fuel bed. This definition makes it unnecessary to have any special or novel form of furnace, or to practise any so-called skilful method of introducing the fuel into the furnace. It follows, therefore, that any furnace may burn coal smokelessly, insofar as the nature of its structure is concerned, and it is necessary only to provide a sufficient supply of properly distributed air to a proportional thickness of fuel bed.

Economical use of fuel is another matter and does not necessarily follow when smokeless combustion is established. It is dependent upon the boiler as well as upon the furnace, and either the boiler or the furnace may be the cause of fuel waste, even though the fuel is being burned smokelessly. The maximum boiler and furnace economy is obtained when the fuel is completely oxidized with the minimum amount of air, and the boiler is delivering the gases to the uptake at the minimum temperature. It will be evident then that both the economical use and smokeless combustion of fuel are dependent upon certain fixed conditions in the boiler plant, relative to the supply and distribution of air to the furnace, and upon a certain thickness of fuel bed. These are factors which belong distinctively to the engineer to determine and fix, equally with his responsibility for the setting of the valves of his engine. The fireman will then only be required to maintain a level fire of a certain thickness. Any ability he may have beyond that necessary to do this, insofar as the combustion is concerned, is only fitting him for the higher position of engineer. If, however, he is a skilled fireman, he has the ability to fix conditions so that economic and smokeless combustion results, and he deserves something equal to a first-class engineer's license.

E. A. Uehling, of Passaic, N. J., was unable on account of sickness to be present, but was represented by his son, F. F. Uehling, who described the gas composimeter or CO_2 recorder and pyrometer installed upon the stage. Mr. Uehling, Sr., had prepared a paper upon

The Combustion of Coal,

in which he said in part:

In practice theoretically perfect combustion is impossible, but complete combustion is attainable, and to produce the greatest useful heat effect it should be accomplished with a minimum excess of oxygen.

The rapidity of combustion depends upon the temperature of the furnace and the quantity of oxygen supplied. The total heat energy liberated per pound of a given coal, however, is independent of the rapidity of combustion, provided combustion is complete. In the burning of coal the decomposition always precedes combustion; hence the greater the amount of volatile combustible contained in a coal the greater the flame volume, and the greater the length of flame, the greater the loss of heat from radiation and the probability of incomplete combustion because of low flame temperature.

Incomplete combustion results from three causes—low-flame temperature, stratification of air and the volatile gases, deficiency of oxygen or insufficient air supply. In boiler practice the latter cause is of rare occurrence. Stratification is caused by incompetent or careless firing, leaving an uneven fuel bed; the air, following the course of least resistance, rushes through the light spots in excess of the requirements and in inadequate quantities through the heavier portions, resulting in strata with oxygen in great excess and strata with a deficiency of oxygen, all below the temperature which would result from proper intermingling of the air with the combustible gases—the one because of a deficiency in combustible and the other because of a lack of oxygen; all becoming quickly cooled below the point of ignition by giving up their heat to the boiler before opportunity for combustion is offered by proper intermingling.

If a luminous flame is brought into contact with a cold body, smoke and soot invariably result. The same results take place if the flame temperature is reduced from any other cause, such as rapid radiation or admixture of an excess of cold air. Too great an excess of air is a prolific source of incomplete combustion. If too much air be mixed with the gas in a furnace, combustion will cease, because the heat absorbed by this air reduces the flame temperature below that required for ignition.

The products of combustion, CO_2 and H_2O, are unstable in the presence of incandescent carbon, and the taking up of an additional atom of carbon by each of them is an endothermic or heat-absorbing action, lowering the flame temperature. While the resulting product is a combustible gas, the addition of sufficient air to effect that combustion may result in further cooling the flame below the point of ignition, and CO and H go off without being burned.

In order to know what is going on in the furnace one must determine the composition and temperature of the flue gases. For practical purposes it is sufficient to know the per cent. of CO_2.

To say that 15 per cent. of CO_2 necessarily indicates maximum economy is absurd. To contend that a knowledge of the percentage of CO_2 in the flue gases is of no practical value is even more absurd.

Sporadic determinations of CO_2 are of small value, and unless judiciously taken may be even quite misleading. Even a proper percentage of CO_2 in an average sample spread over a day's run is no guarantee of regular and efficient stoking. At intervals the CO_2 may have been too high, at other intervals too low for efficient work. These uncertainties are eliminated by employing an apparatus which will continuously indicate

and autographically record the percentage of CO_2 contained in the flue gas.

How to Get Efficient Firing

Lewis Sanders, representing the Sarco apparatus, said that aside from the leakage of the air through the setting the flue-gas temperature shows whether the boiler is doing its share of the work properly or not. The application of recording instruments to the flue temperature is not necessary. The conditions that affect the flue-gas temperature change very slowly, and if this temperature is taken perhaps twice a week, all the information that is of any value in the operation of the plant from that source can be obtained. The only case where he would advise installing an indicating pyrometer would be where the flues are so located as to make it difficult to take the temperature. In the ordinary case a simple mercury thermometer, shell clad, and reading to 1000 degrees Fahrenheit gives all the information that is wanted. The furnace is different from the boiler in the fact that its efficiency is partly dependent on construction and partly dependent upon operation. For construction it is dependent very largely on the complete combustion of the fuel, because that is largely a matter of proper combustion space, with proper baffling walls so as to permit the thorough mixing of the gases and complete combustion before they come in contact with the water-cooled surfaces of the boiler, which very rapidly check combustion and produce very large quantities of CO if combustion has not been completed at that time.

If the furnace is well designed in this respect and the baffling walls are kept in good repair, the fireman has, comparatively speaking, not very much to do with the complete combustion of the coal. From the operating end the furnace is affected very largely by the quantity of air with which the coal is consumed. That is really the essential point which the fireman controls. I do not mean to say that a poor fireman with a furnace that is just on the ragged edge between being a good furnace and an indifferent furnace won't send a great deal more unconsumed coal up the stack than a good fireman, because a good fireman can do a great deal to alter bad conditions; but that is no excuse and no reason for having a bad furnace to start with.

The function of recording apparatus of all classes, including CO_2 recorders, is simply to furnish information on which action can be taken. There is practically no piece of recording apparatus that does anything but this. If records are made simply for the sake of having them on file, they are a waste of money. A record that is not acted upon every day is a useless record.

A first-class fireman can keep up to within about 2 per cent. of the efficiency he could maintain with the aid of a CO_2 recorder. He had made test after test where they had done it. The CO_2 recorder, therefore, should be credited with a saving of about 2 per cent. only of the fuel. That does not mean that all plants are run within 2 per cent. of the economy that can be obtained, many being run 5, 10 and even 20 per cent. below what good practice will obtain, but of that 20 per cent., 18 could be gained by good supervision. Then it becomes a question of the most economical way of obtaining that supervision. In a small plant the best plan is to have a good man on the job. He would not recommend a CO_2 recorder on a plant which burns less than $25 worth of coal per day.

On larger plants where a number of firemen are employed, with a boss fireman over them, a recorder may become a source of economy because the boss fireman with the aid of scientific apparatus can improve his efficiency, and that efficiency where they burn large quantities of coal may be well worth the trouble and expense of obtaining.

The New York Edison Company has adopted a novel system for burning anthracite at its Waterside station. They never clean the fires at all. They have a forced-draft equipment and carry up to 2½ inches. They never let the fire get below 6 to 9 inches thick. They build up the fire until it is about 18 inches. They shake down until the surface of the fire begins to crack, which occurs when it has been shaken down to 6 or 8 inches above the grate bars. They then fire very heavily over the entire surface and then build up to a bright white, so as to get a thoroughly sound fuel bed to start on again, and then go on again firing in the ordinary way until they build up to about 18 or 20 inches.

At the Bureau of Steam Engineering in Washington they have had records taken during the past year on large battleships and cruisers. There are a half dozen cases of duplicate ships, identical in all respects and nearly identical in service, where the fuel consumption varies up to 25 per cent., due to the bad condition of auxiliary engines. The Navy Department has been making a thorough investigation of the state of the furnaces by means of the Orsat apparatus, and they were surprised to find the amount of air which leaked into their steel-set furnaces. As fast as they have checked up the ships and repaired the apparatus, they have cut down the coal consumption and have now an improvement of something like 25 per cent. in the operation of the ships which have been overhauled.

The current practice of sticking to 10 or 12 pounds of coal per square foot of grate per hour should be changed. Buckwheat coals can be burned up to rates of combustion of 27 to 30 pounds per square foot of grate. Plants carrying steady loads can be designed to burn up to perhaps 15 or 18 pounds steadily. In plants having moderately light loads during the day and heavy peak loads, the grate surface should be proportioned so that during the peak load the rate of combustion would be as high as 25 pounds per square foot of grate.

The conditions as they exist in the East require very different types of furnace construction from those in the West. Here an ordinary tile-roof furnace should readily give 70 per cent. boiler efficiency With Manning boilers he had obtained as high as 75 per cent., with coal containing 18 per cent. of volatile matter. With the same type of furnace used on an Illinois coal which runs up to 35 and 40 per cent. volatile matter the efficiency will drop to perhaps 60 per cent., or even to 55, due entirely to the fact that the flaming gases have not had time to be intimately mixed with air, and the flame is extinguished by the cold surface before combustion is completed. A number of furnaces have been tested out in the West, some with very excellent results as high as 70 per cent., with furnaces having double combustion chambers with heavy baffling piers in them, and coals running upward of 35 per cent. volatile matter.

Discussion

The discusion turned largely upon the value of the continuous record, some of the contestants insisting that an indication of temperature or of CO_2 to be of value must be acted upon immediately, while others claimed that the continuous record of a plant was of value for locating deficiencies of practice and for the scientific management of the plant months later than the time at which it was taken. The upshot of the discussion was that the plant should be run with the eye upon the record as it is being made, but that the continuous record is of value for study and analysis.

We understand that it is the purpose of the *New England Engineer,* under whose auspices the meeting was conducted, to print the papers and discussions, which are here presented only in abstract, in their entirety and to furnish them in pamphlet form gratis to those who may apply.

If the water-power sites now owned by the Government—and there are enough of them—shall be disposed of to private persons for the investment of their capital in such a way as to prevent their union for purposes of monopoly with other water-power sites, and under conditions that shall limit the right of use to not exceeding thirty years with renewal privileges, it would seem entirely possible to prevent the absorption of these most useful lands by a power monopoly.—*President Taft.*

Steam Boilers and Combustion*

Principles upon Which Boilers Are Constructed. Variety of Types. Outline of the Essentials of Combustion. The Chief Factor in Boiler Efficiency

BY CHARLES EDWARD LUCKE†

All steam-power systems, whether designed for land or marine transportation or for stationary work, contain the same primary elements for obtaining motion from steam under pressure. But besides the elements, there are hundreds, yes, even thousands of parts, each put in place for a definite purpose, which may be generalized under the heading of better or more efficient service under some special local condition. Even the essential elements, similar as they are, do themselves differ vastly in detail; generally with good reason, but, of course, sometimes without. Because of the greater variety and inclusive nature of the steam-power machinery designed for stationary work, principal attention will be directed toward these, but not so much for the purpose of demonstrating the variations in details as to indicate the principles that once established lead to these forms, which are truly, ideas clothed in metal.

The essential elements of a steam-power plant are a steam-generating part, and a steam-using part. The first part must make as much steam as possible with a pound of coal, and the second must do as much work as possible with a pound of steam. The steam-generating equipment will consist of a boiler, means of feeding the boiler with water and supplying it with coal, a furnace adapted to burn that coal, a flue to carry off the gases of combustion, a damper to regulate the fire and hence the rate of steam making, and means for creating the draft by which the furnace is supplied with air, together with certain other trimmings or accessories such as glass tubes for showing the water level, safety valves for preventing the pressure from rising too high and connections for blowing out sediment that may collect. The steam-using equipment will include the engine and the piping for conducting the steam to and away from the engine. The piping systems are oftentimes extremely complicated, especially when many engines and many boilers are connected together and these located on different floors of the same building. In some plants there are as many as 90 large boilers under one roof. The engine proper consists essentially of either a combination of cylinder, piston and valves to admit and expel the steam, or nozzles and vane wheels, together with a lot of mechanisms to regulate its speed, lubricate its bearings, permit of adjustment for wear and prevent the leaking of steam from joints.

Even for stationary work, there are available today on the American market, hundreds of different makes of boilers and engines. The capacity of engines varies from a fraction of a horsepower to approximately twenty thousand horsepower. Large engines are confined to the largest plants, are seldom used singly and are always supplied by a larger number of boilers which have a capacity seldom exceeding 500 and in a few cases 1000 horsepower each. It has been found by experience that the larger a steam engine, other things being equal, the less steam it will consume in an hour to maintain the horsepower. This is the reason why a few large engines in places where there is a great demand for power, have supplanted a larger number of smaller ones. But this concentration to get better steam economy cannot be carried too far because any engine, unless it is doing an amount of work somewhere near its capacity, is wasteful of steam and at certain times of the day or certain seasons of the year the demand for power is less than at other times.

If there were just one engine in a large power station it would be wasteful of steam during the time of smaller demand, however economical it might be during those times when the demand is about equal to that for which it was designed. With boilers there appears to be little change in economy with the difference in size, and it is more convenient to fit into available spaces and maintain many small boilers than a few large ones.

The controlling idea not only in plant construction and operation, but in the selection and form of every single part, is economy. Economy not only of coal alone but everything taken together, each at its proper value, not forgetting suitable service. Curiously enough, it appears that some of these conditions are contradictory. For example, if space be valuable, as it is in torpedo boats, the boiler must be made light, in which case it is difficult to make it economical. Similarly, if the engine must be highly economical, it will invariably cost more to make than one less economical. When the service is to be temporary only a small first cost is warranted. When labor is difficult to secure or the place of operation dirty, then there must be a minimum of complication and no delicate parts; when fuel is expensive the investment for machinery may properly be high if coal can be saved thereby, but the apparatus may become complicated and require much skilled attention, the cost of which may overbalance the coal saved. These different conditions and many others not mentioned have contributed to the development of great variety in the form of engines, boilers and auxiliaries. Every separate case of power requirement must be studied to find the controlling condition, which, when satisfied, will yield power with the least cost all around, and the determination of which is a problem more difficult to solve than that which Watt had to decipher when he tried to produce the first rotative steam engine.

It seems as if there ought not to be any difficulty in constructing a vessel in which to boil water to make steam, and yet there is no more difficult problem for the engineer to solve when there is added the condition that the boiler shall be economical as well as otherwise adapted to the multitude of different conditions under which it has to work. Consider a plain tank; the water immediately over the fire becomes heated and rises, because it is a little lighter than the rest of the water, and colder water comes down around the sides. This movement of water is called convection and indicates that whenever a mass of water is unequally heated there will be currents set up. These currents in boilers give what is known as circulation or an automatic flow from one part of the chamber to another. Boilers are designed so as to promote and make use of this circulation and care is exercised in fixing the form of boiler and location of fire so as to avoid any interference with it. The observance of this principle of circulation, the discovery of which took a long time, is now quite essential to the making of good boilers capable of yielding great quantities of steam without moisture. It is easy to understand why the earliest boilers were just plain tanks set over grates, with flues running under them and along the sides so as to keep the hot gases in contact with the shell long enough for them to give up their heat to the water. It did not take long to discover that in order to make very much steam the tanks would have to be pretty large and there are cases reported in which these tank boilers were 40 or 50 feet long and had a capacity of only a few hundred horsepower, a condition quite impossible when the cost of making them is considered, not to mention the floor space which they would occupy. To reduce the size and still present enough surface of contact to the

*Third Hewitt lecture, delivered in Cooper Union hall, February 21.

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hot gases, large tubes, or flues as they were called, were introduced into plain shells and all sorts of queer shapes of shells were tried. The use of high pressures forbids irregular forms of shells, as they burst too easily, so that from the time high pressures came into use we find nothing but cylindrical shells with flues or tubes. In one of the early flue boilers the grate is under one end and the gases having passed down under the boiler return to the front again through the flue. In another case, the fire is made in the flue and passing down through the center discharges back along the sides. Reducing the diameter of the flues and placing a number in each boiler very materially increases the heating surface and steaming capacity of the same sized shell, and such a construction constitutes the modern, horizontal, return-tubular boiler, which is today the type most widely used in stationary work.

It has been found necessary in marine service to avoid brick settings. This condition is met by using in the lower half of the boilers large flues in which the fire is contained, the gases passing to the back and returning through a bank of tubes in the upper part of the shell. This construction is known as the Scotch boiler and is the type most widely used on steamships.

A sort of intermediate type of boiler, adapted for locomotives, is one in which one end of the boiler is made square to form a fire box of metal plates surrounded by water, from which the gases pass through straight tubes to the stack in front. With minor modifications, this is the type almost universally used for locomotives, its form being well adapted to fit on the frame above the wheels.

In the three classes of boilers mentioned, the gases pass through the tubes and they are, therefore, known as fire-tube boilers. In some of them, as in the Scotch-marine and in the locomotive, the fire is also within the boiler; and they are said to be internally fired.

In fire-tube boilers the circulation is not considered as effective as it might be. In general, the water is rising from all the hot tubes, the steam bubbles escaping from the surface of the water all over the center of the top. The water thus carried up by the bubbling forms a sort of hill in the middle, perhaps concentrated toward one end, from which the water runs down the sides of the shell or the other end, back to the bottom to supply the tubes from which the steam has escaped. With a view largely to improve the circulation, but for other reasons as well, a different type of boiler has been developed in recent years, known as the water-tube type. In its horizontal form, it consists of top drum with two narrow boxes extending downward from it, one at each end and a bank of inclined tubes connecting these approximately vertical, narrow boxes, which are termed water headers. Water fills the lower third of the drum and all of the tubes and headers. As the fire is placed under the high end of the tubes, the water is forced to rise through the front header, discharge its steam and descend through the rear header back to the hot tubes. To insure sufficient time for contact between the hot gases and the water-heating surface, tiles are placed between the tubes, making baffles which direct the gases from the fire upward across the tubes, then down and finally up again. The horizontal, water-tube boiler consists of straight tubes, which are more easily cleaned than curved ones. It must be remembered that all water used in boilers contains dissolved salts which, by the continuous boiling away of the water are left behind in a solid state. This solid matter collects in two ways, as loose sediment or mud which can easily be blown out, and as a hard layer of stone-like scale sticking to all the surface where boiling takes place and interfering with the flow of heat through the tubes. A deposit of scale in a tube of a horizontal, water-tube boiler can be removed by running a scraper through the tube, an operation which is practically impossible with some other constructions. When there is plenty of head room or a shortage of floor space, a different design of boiler may be used and what is called the vertical water-tube boiler, in a variety of forms, has been designed and is much used; for example, by the large steel mills in which will be found dozens of them set in a single row.

Perhaps the most severe conditions of space and weight conservation are found in steamships intended to go at high speeds. Both fire-tube and water-tube boilers are used; the fire-tube type used has already been mentioned. The water-tube class is represented by several different forms, some of which have straight tubes and others, curved tubes; the curved-tube type, however, is mainly confined to torpedo boats where the conditions are most severe with regard to space and weight limitation. In all cases, marine boilers have the grate underneath the entire boiler. No brickwork is used because of its weight, the boiler being inclosed by sheet metal and layers of nonconducting material. Special attention is paid to circulation, and the same principles are followed as in land practice.

In addition to the difference in form, total space occupied, floor space occupied and weight per horsepower, boilers differ in cost per horsepower fully 100 per cent. between the cheapest and most expensive. The most expensive boilers are those which have the most handwork on them, the greatest number of separate parts to be made and fitted together; the cheapest are those which have the least work for the amount of surface available for heating. There is, likewise, some difference in efficiency which is measured by the number of pounds of water that can be evaporated for each pound of coal burned or the amount of heat that can be put into the form of steam for each unit of heat that the coal should liberate on combustion. Strange, indeed, it is that enormous variation in form produces little variation in efficiency so that all forms may be said to have about the same efficiency if each is worked under its best conditions. The efficiency ranges around 70 per cent., falling as low as 60 and rising as high as 80 with some rare cases beyond these limits. This means that the steam which leaves the boiler contains about 70 per cent. of the heat liberated by the combustion of the fuel; a performance which is reasonably good and due more to the management of the fire, based on an understanding of the conditions necessary for proper combustion of the fuel than to the design of the boiler.

There is scarcely time available for studying all the conditions of combustion, recognition of which so largely controls boiler performance, but two important points will be mentioned. All the fuel supplied must be burned, and any furnace or fireman that does not permit it all to be burned is wasteful not only of the coal but also of time and the investment required to build the boiler. Whatever coal is burned requires a definite amount of air which is different for different coals. Combustion is a chemical combination of coal and air. In all chemical combinations the original substances combine with each other in a fixed weight ratio. Each pound of coal then, will require a definite weight of air chemically to combine with it. If this amount of air is not supplied, all the coal will not be burned; if more is supplied, the coal may burn all right, but even greater harm may result than when the air is insufficient. Heat liberated by the fire will warm anything that comes in contact with it. If balls of iron were rolled into the fire and rolled out again they would carry away heat that should have been used for making steam. If a stream of water was turned into the fire and if it was not too large it would not put the fire out but it would rob the fire of heat in just the same way as did the balls of iron. Finally, if a lot of cold air, more than is needed to burn the coal, is drawn into the fire, it escapes up the chimney, carrying off, in a like manner, some of the heat that should have found its way into the water. Excessive air, as it is called, has just as much harmful effect on the efficiency of a boiler as a stream of water, played on a fire, would have. Upon the control of this excess air the efficiency of a boiler depends more than on any other single thing.

Interesting Surface Condenser Tests

BY J. A. POLSON

The data from which these results have been worked up were taken by the senior class in the engineering laboratory of Michigan Agricultural College, East Lansing, during the past year, under the supervision of the writer. The condensers referred to in this article are of different design and the results obtained will give a general idea of the behavior of each. Condenser No. 1 has direct flow, that is, the cooling water makes but one pass through the condenser. It has 104 three-quarter-inch No. 20 gage brass tubes tinned inside and outside. The total cooling surface of tubes is 122 square feet. Condenser No. 2 is of the return-flow type. The cooling water upon entering flows along the bottom through 133 tubes and returns along the top through 128, making 261 five-eighths-inch No. 18 gage brass tubes tinned inside and outside. The cooling surface of tubes is 300 square feet. During the test conditions were maintained as nearly uniform as possible. The steam was supplied by an engine under test where the brake load was kept constant. The average length of the tests was 50 minutes, with 10-minute readings. The condensed steam was weighed in tanks on platform scales.

On condenser No. 1 the cooling water was measured by means of a Venturi meter reading in cubic feet per second. On condenser No. 2 the cooling water was measured by a sharp-edged circular orifice placed in the bottom of a receiving tank. The rate of flow was determined by reading the hight of the water above the orifice and calculating the flow. The results have been tabulated and perhaps need a word or two of explanation. One hour was taken as the basis for computation. Thus column 2 gives the pounds of steam condensed per hour during the various tests, column 3 the temperature of condensed steam, and column 4 the vacuum in the condenser in inches of mercury.

No attempt was made to obtain a heat balance, and the B.t.u. used in calculating the various items were taken as equal to the rise in temperature in the cooling water times the number of pounds of water per hour.

In the results three averages are given: the average of the three tests *H*, *I* and *L* on condenser No. 1, and *O*, *U* and *W* on condenser No. 2. These three tests show the largest hourly quantities of steam condensed. All items cannot be compared directly because of the different sizes of the condensers and other conditions, as vacuum, etc. But condenser No. 1 having only 122 square feet of surface condensed one pound of steam at a vacuum of 10.4 inches mercury, with 14 pounds of water at a temperature of 36 degrees Fahrenheit, while condenser No. 2 having 300 square feet condensed one pound of steam at a vacuum of 23 inches mercury with 16.8 pounds of water at 39 degrees Fahrenheit. These results are still more striking when one considers that No. 1 condensed 16.33 pounds of steam per square foot per hour, while No. 2 condensed only 5.23 pounds per square foot per hour.

No reference has been made to the amount of cooling surface per horse-power, because so much depends on the engine. This can easily be determined when the pounds of steam per horsepower per hour are known. In this case, condenser No. 1 received steam from a tandem-compound slide-valve engine developing a horsepower-hour on about 45 pounds of steam, while condenser No. 2 received steam from a Corliss engine developing a horsepower-hour on about 19 pounds of steam, which shows that the capacity of the condenser must depend on the steam consumption of the engine and not on the rated horsepower.

RESULTS OBTAINED IN CONDENSER TESTS.

	Test.	Condensed Steam.		Average Vacuum in Condenser.	Cooling Water.											Cooling Surface	
					Total per Hour.			Temp. Deg. F.									
		Total per Hour, Pounds.	Temperature, Deg. F.		Cubic Feet.	Gallons.	Pounds.	Inlet.	Outlet.	Increase.	Per Lb. of Cond. Steam.	Total B.t.u. Absorbed per Hour.	B.t.u. Absorbed per Lb. of Cond. Steam.	Lb. per Single Tube per Hr.	Velocity in Ft. per Min. Through Tubes.	Steam Condensed per Sq. Ft. per Hour.	B.t.u. Absorbed per Sq.Ft. per Hour.
Condenser No. 1.	A	1,700	183	11	404	3,021	25,000	37	110	73	14.7	1,825,000	1,073	240	27.6	13.92	14,950
	B	1,800	190	10	398	2,977	24,628	34	111	77	13.67	1,906,360	1,052	237	27.2	14.75	15,610
	C	1,900	190	10	423	3,164	26,167	33	108	75	13.7	1,962,560	1,028	255	28.8	15.56	16,100
	D	1,735	193	7¾	349	2,615	21,600	34	113	79	12.5	1,696,400	988	208	23.8	14.22	13,900
	E	1,950	198	7	374	2,795	23,150	33	114	81	12	1,875,150	972	222	25.6	16.00	15,360
	F	2,155	191	9	400	2,992	24,700	33	117	84	11.5	2,064,800	966	237	27.3	17.65	16,460
	G	2,133	190	10	570	4,260	35,300	38	107	69	16.5	2,435,700	1,138	340	38.9	17.46	19,920
	H	3,042	193	8	630	4,720	39,035	37	105	68	13	2,654,380	884	376	43	25.00	21,700
	I	3,110	193	9	670	5,020	41,500	34	105	71	13.3	2,964,500	944	399	45.7	25.50	24,100
	J	1,546	172	16	457	3,420	28,340	47	100	53	18.3	1,502,000	971	272	31.2	12.70	12,310
	K	1,806	177	15	475	3,550	29,500	36	99	63	16.3	1,848,500	1,042	283	32.4	14.80	15,100
	L	2,240	183	13	500	3,740	31,000	36	100	64	13.8	1,984,000	884	298	34.1	18.36	16,250
	Average of H, I, L.	2,797	190	10	600	4,493	37,178	36	103	68	13.3	2,534,293	904	358	40.9	22.95	20,683
	Average of A, D, J.	1,660	180	11½	403	3,019	24,646	39	108	69	15.2	1,674,466	1,011	240	27.5	13.61	13,720
	General Average.	2,093	188	10.4	471	3,523	28,743	36	107	71	14	2,059,945	995	280	32.1	16.33	16,813
Condenser No. 2.	M	1,150	93	23	370	2,770	22,980	42	92	50	19.9	1,149,000	995	179	25.2	3.83	3,830
	N	1,630	99	22	474	3,540	29,400	40	94	54	18	1,587,600	970	230	37.4	5.44	5,292
	O	2,170	101	22	618	4,630	38,400	40	93	53	17.7	2,035,200	940	300	48.8	7.24	6,784
	P	1,570	82	23	315	2,357	19,600	43	90	47	12.5	921,200	588	153	24.9	5.24	3,071
	Q	1,680	94	24	390	2,920	24,230	40	90	50	14.4	1,211,500	720	190	30.8	5.6	4,038
	R	1,760	97	24½	507	3,792	31,500	40	91	51	17.9	1,606,500	913	246	40.0	5.87	5,355
	S	1,000	101	24	296	2,216	18,340	40	106	66	18.3	1,210,440	1,210	143	23.3	3.33	4,034
	T	1,640	118	23	375	2,805	23,240	36	105	69	14.1	1,601,000	973	182	29.6	5.46	5,333
	U	2,360	125	23	507	3,792	31,400	35	108	73	13.3	2,292,000	972	245	40.0	7.87	7,640
	V	1,350	92	23	396	2,960	26,600	36	91	55	18.2	1,355,000	1,000	208	31.2	4.5	4,516
	W	1,860	97	23	507	3,792	31,500	36	92	56	16.9	1,760,000	946	246	40.0	6.2	5,866
	X	890	81	22	302	2,259	18,766	40	89.5	49.5	21	928,900	1,039	146	23.8	2.96	3,096
	Average of O, U, X.	2,130	108	23	544	4,071	33,766	37	98	61	16	2,029,066	933	264	42.9	7.1	6,266
	Average of M, S, W.	1,013	92	23	323	2,415	20,028	41	96	55	19.7	1,096,113	1,081	156	24.1	3.77	3,653
	General Average.	1,588	98	23	421	3,152	25,913	39	95½	55	16.8	1,471,528	939	214	33	5.23	4,904

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Exhaust Steam and Central Station Service

Suppose that running by a mill site was a stream capable of developing one thousand horsepower all the time the mill was running, and that it could be cheaply developed. If the mill had no use for steam for heating or any other purpose its designer would be foolish to put in a steam plant and let the water power run to waste.

Suppose the mill in heating and manufacturing processes had use for a lot of steam at ten pounds pressure. It would cost very little more to make this steam at 150 or 180 pounds than at ten, some 37 heat units per pound in a total of nearly twelve hundred. One pound of steam in expanding from 195 pounds to 25 pounds, both absolute, liberates 152.6 heat units, and 88 per cent. of it is still steam at the lower pressure; that is, about 12 per cent. has been condensed by the conversion of its heat into work. The condensate is at 240 degrees and will serve for some of the purposes for which heat is required, but if 26,400 pounds of dry saturated steam at 25 pounds absolute are required per hour they may be made by evaporating $26{,}400 \div 0.88 = 30{,}000$ pounds of water into steam at 195 pounds and expanding it to the lower pressure through an engine. In doing this $30{,}000 \times 152.6 = 4{,}578{,}000$ heat units would be liberated for conversion into work, which would develop 1000 horsepower in an engine of only 55.5 per cent. efficiency.

If then this amount of low-pressure steam must be had anyhow, and boilers must be provided and operated to supply it, the simplest and cheapest means of getting the power for the mill is to evaporate the small amount of extra water at the slightly additional cost in heat units per pound and utilize the flow of heat from this higher level to the lower level set by the needs for heating and manufacturing purposes, for the operation of the motor. The investment in boilers once required, the use of the higher pressure will establish a heat fall as potent as that of the water fall, at a combined cost for development and maintenance probably less than that of the hydraulic system.

With such a stream of heat flow so easily made available at a practicable head, an engineer would be more foolish to cut out his engine plant and buy current from a central station than he would be to develop an expensive water-wheel plant.

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At a discussion of this subject at a combined meeting of the American Institute of Electrical Engineers and the American Society of Mechanical Engineers at Boston recently, a report of which will be found on page 393, Dugald C. Jackson remarked, "The requirements for heating mills and the use of steam in various manufacturing processes often make it impossible to remove the means for generating steam from the factory site, but the generation of steam for power purposes is commonly accomplished separately on account of the different pressures needed for the two purposes, and the separation is therefore a matter to be dealt with as of manufacturing convenience rather than as controlled by economy of steam generation." The making of steam at a low pressure is justified only when no further power is required, and it is hard to imagine a case where it would be good engineering to buy power and run a boiler plant to make low-pressure steam.

Skilful Firemen

One of the speakers at the recent combustion symposium in Boston rather disparaged the value of skill on the part of the fireman.

"The economic use and smokeless combustion of fuel," he says, "rest entirely upon the conditions under which the combustion is carried on, and the average fireman's lack of 'skill,' so-called, does not affect these results in any measurable degree. His wilful neglect may defeat the attempt at economic use and smokeless combustion of fuel, but his lack of so-called 'skill as a fireman,' never!"

He goes on to say that "both the economic use and smokeless combustion of fuel are dependent upon certain fixed conditions in the boiler plant relative to the supply and distribution of air to the furnace, and upon a certain thickness of fuel bed. These are factors that belong distinctively to the engineer to determine and fix, equally with his responsibility for the setting of the valves of his engine. The fireman will then only be required to maintain a level fire of a certain thickness. Any ability he may have beyond that necessary to maintain a level fire of a definite thickness, insofar as the combustion is concerned, is knowledge fitting him for the higher position of engineer."

And yet when the "combustion engi-

neer" and the "designing engineer" have got all through with their choice of fuel and designing a furnace to burn it, and the "operating engineer" has been around and given his directions as to method and management there will be good firemen and poor firemen on the same plant; men who will have the steam gage wandering all over the dial and men who will hold it at or near the desired pressure through all the variations of load; men who will send clouds of smoke into the air and men who run clean stacks, men who evaporate six pounds of water with a pound of coal and men who evaporate ten. The poorer results may be due to "wilful neglect," carelessness, failure to understand and carry out directions or simple lack of intelligent interest; but the aggregation of qualities which produce the good results may reasonably be referred to as plain "skill."

Unaccounted for Losses

Frequently there are losses connected with the regular use of steam-plant apparatus that are never shown directly by special tests made to determine the operating economy, and these can only be included with the other features, good and bad, in the general result obtained in a regular operating test continuing over a considerable period of time. A good example of this kind of loss which admits of being fairly well estimated, is that due to heavy brick settings for boilers. The average horizontal tubular boiler of 200 horsepower capacity requires about 120,000 pounds of brickwork to properly set it, and the weight of water contained is about 20,200 pounds; the weight of the boiler proper is 23,000 pounds. Using the correct values for the specific heats of the three substances involved (brick, steel and water) and assuming an average rise in temperature above the surrounding atmosphere of 400 degrees Fahrenheit for the setting walls and 300 degrees for the water and metal, as representing working conditions, it is found that 16,464,000 B.t.u. of heat is stored in the setting and boiler without being available for useful work.

If such a boiler is operated for ten hours at rated capacity and allowed to cool down, the amount of heat that has been lost in elevating the temperature of the setting, boiler and contained water, amounts to twenty per cent. of the total heat supplied, or nearly twenty-five per cent. of the useful heat absorbed in evaporation, or about 1460 pounds of bituminous coal, if an efficiency of seventy-five per cent. is assumed for the transfer of heat. If such a boiler was operated for a period of sixty hours, or for the usual working week, and shut down, the loss of heat absorbed would amount to about four per cent. of the total heat supplied by the fuel. Comparing this loss with a similar loss for the same size of internal-furnace boiler, there would be 17,800 pounds of water and 31,500 pounds of metal, which under working temperatures assumed the same as for the return-tubular boiler, would represent the absorption of 6,440,000 B.t.u. of heat, or 572 pounds of coal, or about one and one-half per cent. of the total fuel used after a run of sixty hours at rated capacity.

Comparing the two types of boilers under operation for a week's time, the internal-furnace boiler would have the advantage of nearly 900 pounds of coal from its lack of ability to store heat alone.

Another feature that leads to operating economy in a self-contained boiler, as compared with one with a brick setting, but the real importance of which is not indicated by a direct evaporative test, is the radiation loss. While it is, of course, true that the radiation loss is a part of the loss that is directly indicated by an evaporative test, it is a loss which does not cease with the temporary closing down of the boiler, as is customary in the average plant which is operated ten or twelve hours, and the fires being banked the balance of the twenty-four hours; under these conditions, radiation losses as far as plant economy is concerned, are very much more important than their effect on a direct evaporative test would indicate.

Engine Room Floors

Concrete, which is now being used so extensively for engine-room floors, presents quite a problem to the engineer who wishes to keep the appearance of his department up to the standard. It is true that a clean, white, smoothly finished floor of this description is perfectly satisfactory, but few of them remain long in this condition. The highly finished hardwood floors of the old-time engine room were always the pride of the man in charge of the plant. If such a floor became soiled it was merely a question of a little work to restore its appearance, but this does not always suffice in the case of the latter-day engine room, as when once a concrete floor gets spotted with oil it seems next to impossible to get it back into its former shape.

The trouble with concrete floors in many cases can be traced to the very beginning, when frequently the floor is being laid and the engines installed at the same time. Under these circumstances it is almost certain that the finish and appearance of the floor will be spoiled before it gets hard enough to bear any weight. In one plant where the floor was badly needed before it had become set, some genius suggested covering it with a thick coat of sawdust to enable the erecting gang to proceed with the setting up of the engines. It can be imagined that the result was a wretchedly rough, extremely dusty floor surface, and one utterly ruined from the standpoint of appearance.

From those who have made many experiments with concrete floors, it appears that covering with a thick enamel paint is one of the best methods of improving appearances after a floor has become unbearably spotted with oil.

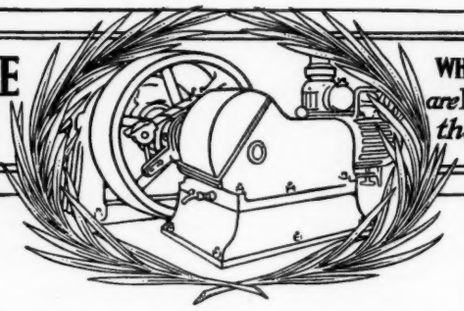
An expedient which has been tried in a few cases, but which, however, can only be used in the case of a new installation, consists of mixing some dark-colored pigment with the cement when the floor is being laid, giving a uniform tint, which does not easily show the dirt. Lampblack has been used for this purpose, and such a floor, smoothly finished and given plenty of time to set before being used, should present a better appearance than the concrete floor of the ordinary engine room.

An Epidemic of Boiler Explosions

Within the past few weeks there has been an unusual number of destructive boiler explosions. A noticeable and suggestive feature of the series is that most of the boilers have been subject to no sort of inspection or supervision beyond that of their users and have failed from causes which ordinarily skilled inspection would have revealed. This cannot go on indefinitely. Steam users will either have to submit to Governmental inspection of their boilers, have them insured, with the consequent inspection, or employ engineers who are qualified to judge of the safety of the apparatus in their charge, make them responsible for it and comply with their advice and requirements.

The Boston School Board has decided to start up the plant at the Mechanics Arts High School and make its own electric current instead of buying it from the electric company at ten cents per kilowatt-hour. When figuring the cost of current the central-station man lays great stress upon the standing charges, interest on investment, etc. Here is a school which has the plant all installed and lying idle while it buys current. Add the standing charges which are already incurred to the ten cents and where does the cost per kilowatt go to? There are lots of plants around New York and New Jersey, mostly in public institutions, which could be started up to equal advantage. They are already paying the bulk of the cost of generating current in investment in idle plant, in running boilers for heating which might as well be making light too, and in the support of attendants who might as well run an engine or two as to pull the switches of an outside connection. For an example look at the State House at Trenton. It is only one of many.

NEW POWER HOUSE EQUIPMENT



WHAT *the* INVENTOR *and the* MANUFACTURER *are* DOING *to* SAVE TIME *and* MONEY *in the* ENGINE ROOM *and* POWER HOUSE

Automatic Gravity Air-Operated Oiling System

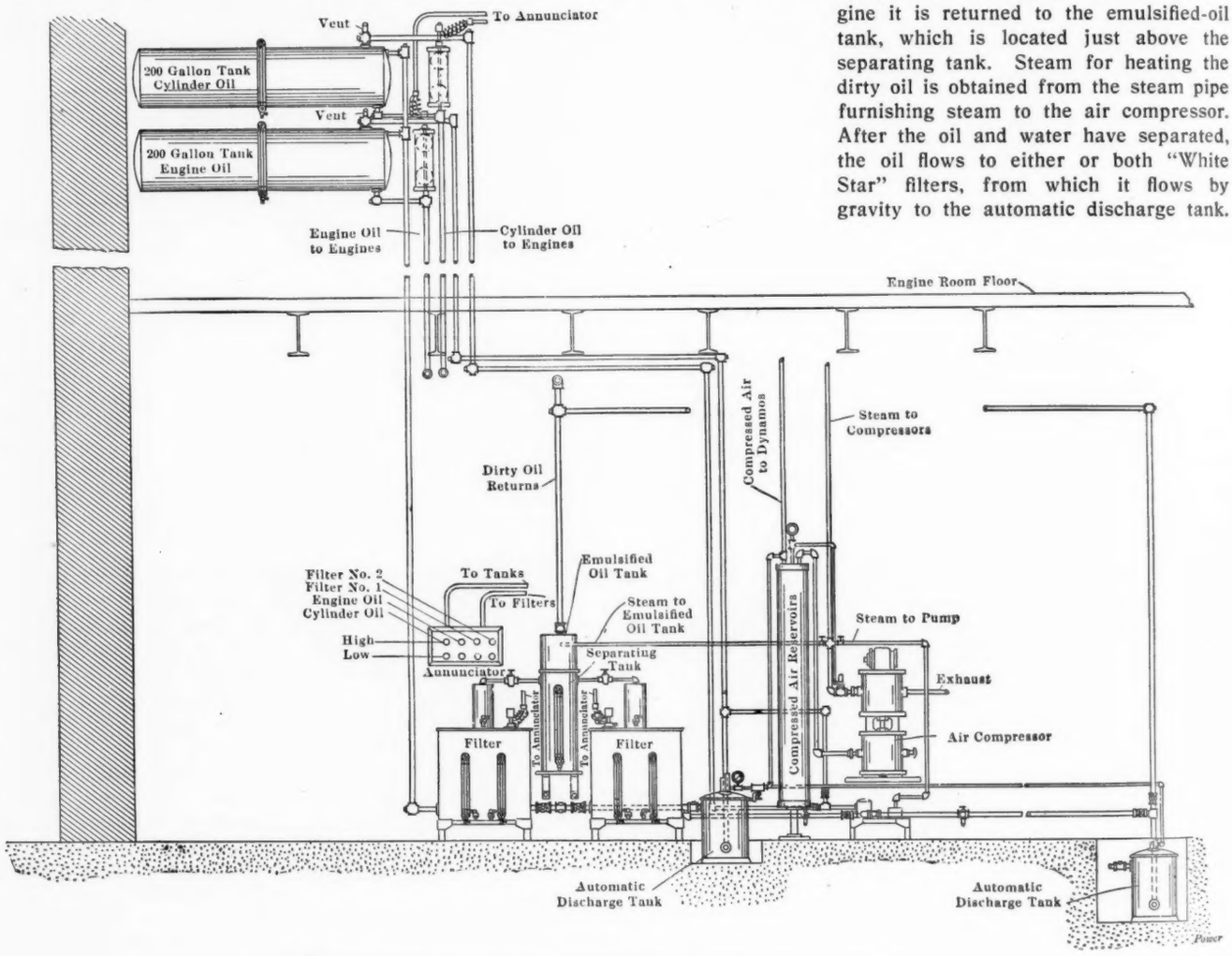
An automatic air-operated oiling system that should appeal to engineers can be found in operation in the new power plant of Johnson & Johnson, New Brunswick, N. J.

The oil-supply tanks are located in the top of the engine room, as indicated in the accompanying illustration. Each bearing of the engine is fitted with suitable connection to the oil main, and the engine oil, besides being piped to the bearing, crosshead, etc., is piped to oil sinks placed between the high- and low-pressure cylinders of each of the three large engines. Another oil line furnishes cylinder oil to the lubricator, while a third pipe line conveys the dirty engine oil to a separating tank and emulsified-oil heater.

The illustration shows an elevation of the filters and other devices necessary to deliver the filter oil to the elevated storage tank, each of which is fitted with a gage glass, the connection of which passes through the brick walls so that only the gage glasses show in the engine room. Each is also fitted with a high- and low-oil alarm, as shown at the end of each tank. It is operated by means of a float, which rises and falls according to the hight of oil in its respective tank. By means of suitable connections, contact is made with the terminals of wires connecting with an annunciator located above the oil filters. If the oil in the cylinder or engine oil tank is too high or low, the proper signal is given, calling the engineer's attention to the matter. The filters are also fitted with the high- and low-oil alarm and connection made with the annunciator.

Oil for the engine is taken from the bottom of the tank through the pipe shown, which is fitted, where possible, with tee instead of ell joints. One end is plugged, thus allowing quick cleaning out of any obstruction that might become lodged in them.

After the oil has been used on the engine it is returned to the emulsified-oil tank, which is located just above the separating tank. Steam for heating the dirty oil is obtained from the steam pipe furnishing steam to the air compressor. After the oil and water have separated, the oil flows to either or both "White Star" filters, from which it flows by gravity to the automatic discharge tank. As the oil rises in this tank it operates an air valve by means of a float, which lifts an inlet-air valve, letting in air at a pressure of 35 pounds. This pressure closes the check valve in the pipe leading to the filters, and at the same time forces the oil to the overhead tank. When the oil has been driven from the discharge tank, the float drops and closes the air-inlet valve and opens the valve to the at-



FEATURES OF AUTOMATIC GRAVITY AIR-OPERATED OILING SYSTEM

mosphere, thus enabling the discharge tank to refill with oil. The air is compressed by a standard type of Westinghouse air pump which pumps air to the compressed-air receiver shown.

The system is flexible as the oil can be returned either from the oil filter or from any independent discharge tank to the emulsified-oil tank. This is done in the case of the engines driving two volute pumps, which are placed in a pit at a considerable depth below the level of the filters, and at the extreme end of the plant. The oil from the two engines flows to the automatic discharge tank, which is connected to the air-pump line, and as the oil lifts the float, the air-inlet valve is also lifted, as in the first case mentioned, and the dirty oil is discharged to the emulsified-oil tank, from which it flows to the filter.

By this arrangement a continuous automatic oiling system is obtained which will stay in operation so long as there is oil in the system. No trouble is therefore experienced with leaky oil-pump piston rods, packing, etc. Oil does not drip down on the floor and the entire arrangement makes a most satisfactory system for the power plant. Air is also piped to the engine room for cleaning out the generators, etc.

The cylinder oil is elevated by means of a small duplex oil pump, pumping direct from the barrel to the cylinder oil tank. This system was installed by the Vandyck, Churchill Company, New York City, and was designed by William Peterson, now of the Peterson Engineering Company, 50 Church street, New York City, which has taken over all work pertaining to oiling systems formerly done by the Vandyck, Churchill Company.

A New Pumping Engine

The accompanying illustration represents one of the vertical triple-expansion Hamilton-Corliss pumping engines built by the Hooven, Owens, Rentschler Company, Hamilton, O., for the pumping station of Brooklyn, N. Y. Fig. 1 shows the steam end of one of the engines and the pump chambers of a 23,000,000-gallon pump. The steam cylinders are all steam-jacketed and the valve gear on the low-pressure cylinder is of the poppet type; see Fig. 3.

It will be noticed that the bedplate is of the box section, and is made deep, massive and strongly webbed, with a liberal bearing surface at the foundation. It is cast in one piece and is carried around the crank at full hight, forming a deep crank pit to retain oil. As indicated in the illustration, the base has easy lines and well rounded corners.

The main-bearing portion is bored and faced to receive the bottom box, which is of the shell type so arranged that it can be removed by raising the shaft enough to remove the weight from the box. This box is designed for water circulation. The A-frame is cast in two pieces and is strongly webbed. It is planed and fitted together with bolts as indicated. The lower portion is of the box or rectangular section, which gradually changes to a circular section as it reaches the top, thus giving very pleasing and strong lines. The openings on the sides are especially designed to receive oil shields which entirely inclose this part of the engine.

The guide barrel is circular in form, slightly flattened on the sides where the openings come, which are also designed for perfect fitting oil shields and doors. This portion of the frame is strongly webbed. The guides are separated from the walls of the barrels by an air space and are bored for a common center.

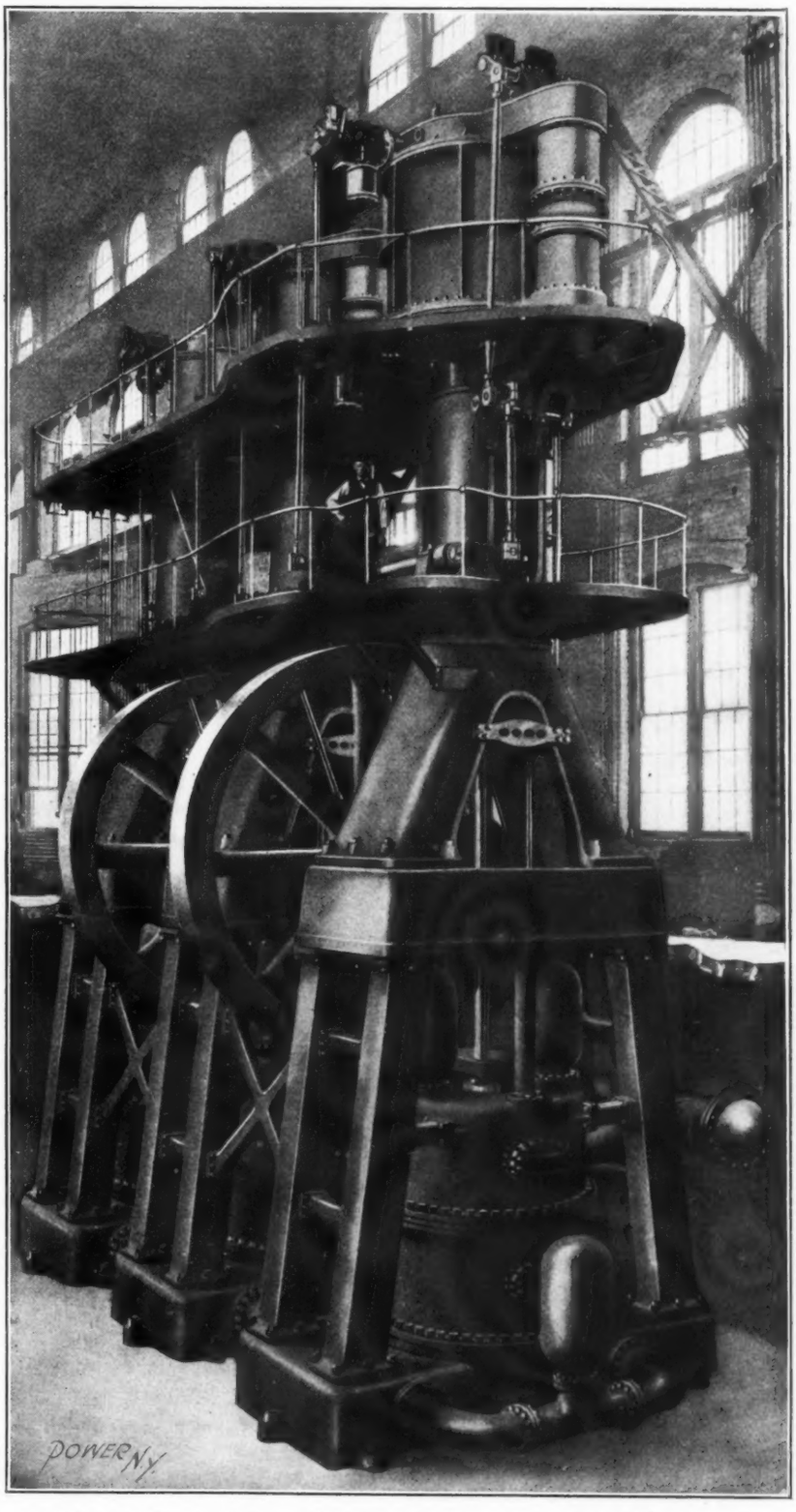


FIG. 1. HOOVEN, OWENS, RENTSCHLER COMPANY'S TRIPLE-EXPANSION PUMPING ENGINE

The valve gear is somewhat different from the regular type of engines manufactured by this company. The exhaust-steam valves are actuated by separate eccentrics direct, without wristplates, as shown in Figs. 2 and 3, the necessary motion being obtained by the use of levers and links on each bonnet separately, thus greatly reducing the strain. The dashpots are hung from the bonnet and are close to the cylinder, which makes a very compact and self-contained arrangement. The dashpots are of the new noiseless pattern, with the weight of the moving parts greatly decreased. Both steam and exhaust cam rods have efficient unhooking devices, so that the valves can be worked by hand to facilitate starting and warming up. The valves are double-ported, with very short travel, therefore eliminating excessive wear. The galleries are of cast iron, strongly ribbed and of symmetrical design. Fig. 3 is an end elevation of the low-pressure exhaust side.

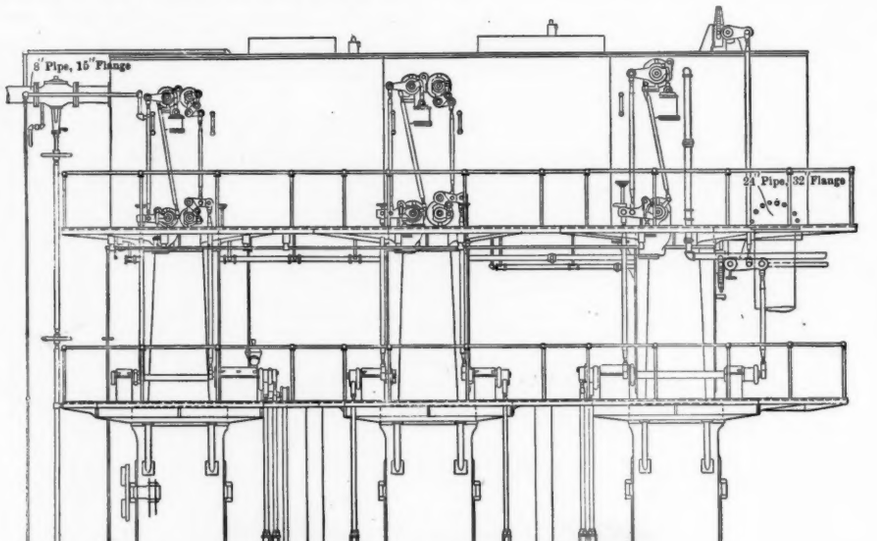


FIG. 2. FRONT ELEVATION OF THE STEAM END

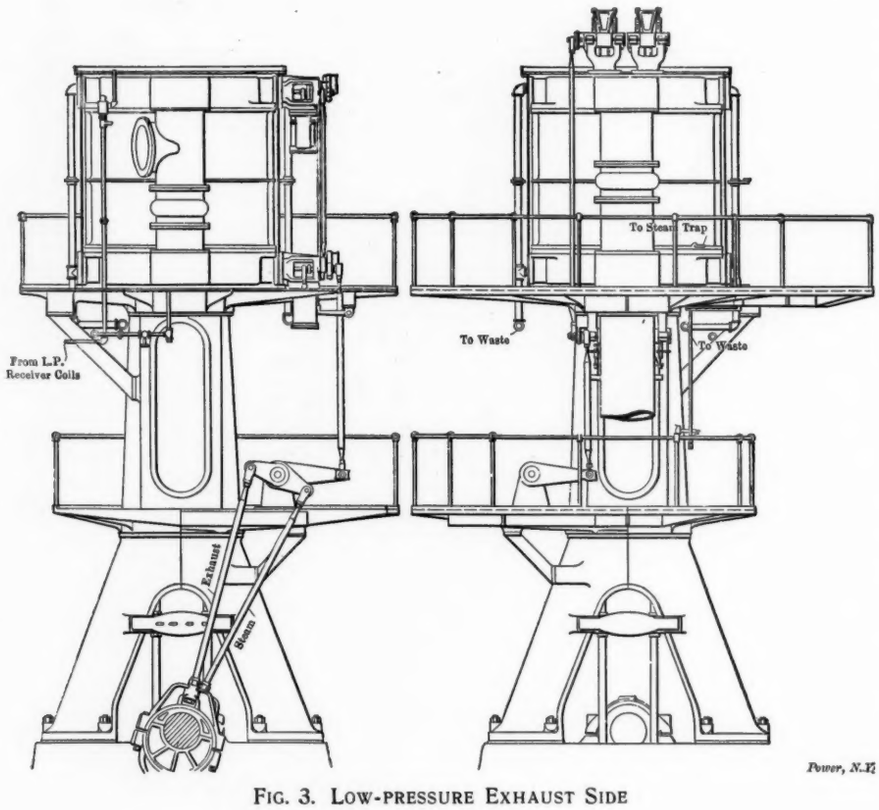


FIG. 3. LOW-PRESSURE EXHAUST SIDE

"Vulcan Bijaw" Wrench

An improvement in the Vulcan chain pipe wrench manufactured by J. H. Williams & Co., 150 Hamilton avenue and Richards street, Brooklyn, N. Y., is shown in the accompanying illustrations. It is known as the "Vulcan Bijaw" wrench.

It is made with the reversible jaws, which can be readily turned end for end when the teeth wear, thus doubling the life and giving an "always ready" service of the tool. Two studs are bolted through the handle to prevent the spread of the jaws when in use. The material in the studs is of great strength, and in case of accident repairs may be made at once by moving forward the rear stud, as one bolt or stud will provide a working strength for the tools.

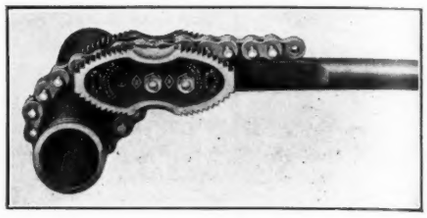


FIG. 1. FLAT-LINK CHAIN WRENCH

All parts are made of wrought steel, are interchangeable and absolutely guaranteed. The flat hand-made chain is of great strength and the jaws are tempered for file sharpening. Commendable features are the central swing of the chain, and the tool always being right side up. Owing to the reversible jaws a service of two or four tools at the cost of one is obtained. It is claimed, that when properly used, this tool will last a life time, and even when abused 90 per cent. of the strongest efforts will be resisted and no crushing of the pipe will follow. This wrench is made in sizes for ⅛-inch to 12-inch pipe and fittings, and with interchangeable cable or flat link chain, the latter being shown in Fig. 1 and the cable wrench in Fig. 2.

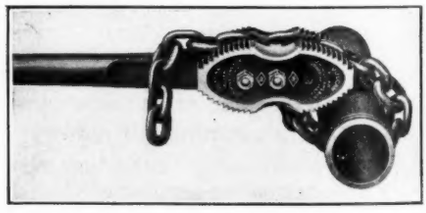
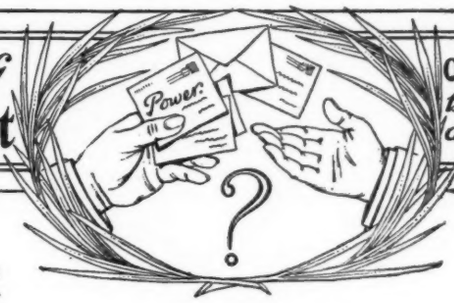


FIG. 2. INTERCHANGEABLE-CABLE WRENCH

Which is the cheaper to develop for power-producing purposes, a stream of water flowing through water turbines or a stream of heat units flowing through a steam engine, the heat exhausted by which at the lower level can be used to advantage for heating and manufacturing processes?

INQUIRIES of General Interest



QUESTIONS are NOT ANSWERED UNLESS they are ACCOMPANIED by the NAME and ADDRESS of the INQUIRER.

Hook in Compression Curve

I frequently get an indicator diagram with sharp drop or a sort of a hook near the top end of the compression curve. What is the cause of it?

T. L. W.

It is frequently ascribed to leakage of piston or exhaust valve. But it is much more likely to result from condensation.

The cylinder is never so hot as the steam that enters it nor so cold as the exhaust and as the steam is compressed it is heated by the cylinder and by the compression, but the heat of compression soon carries the temperature of the steam beyond that of the cylinder and as steam cannot exist in contact with anything colder than itself part of it is condensed. The operation is identical with that of liquefying gas by compression and refrigeration.

Expansion of Pipe and Pump Capacity

1. How can I find the allowance that should be made for expansion in a wrought-iron pipe 325 feet long, if it is erected at a temperature of 70 degrees Fahrenheit, and is to be subjected to a steam pressure of 125 pounds per square inch?

2. If the pipe is exposed to a temperature of 10 degrees below zero, how much shorter will it be than when erected?

3. Kindly let me know if I have the following problem worked out right.

What should be the diameter of the plunger of a single direct-acting steam pump for feeding a 500-horsepower battery of boilers (American Society of Mechanical Engineers' standard of evaporation); the piston speed is not to exceed 100 feet per minute and the actual discharge of the pump is 90 per cent. of the theoretical discharge.

$$500 \times 30 = 15{,}000$$

pounds of water per hour. Adding 15 per cent. and 20 per cent. as a safety factor,

$15{,}000\ (0.15 + 0.20) + 15{,}000 = 19{,}250$ pounds per hour;

$$19{,}250 \times 0.90 = 17{,}325$$

pounds per hour. Water fed per minute equals,

$$\frac{17{,}325}{62.5 \times 60} = 4.62$$

cubic feet, if the average number of strokes per minute is 35.

The water displaced per stroke is therefore

$$\frac{4.62}{35} = 0.132$$

cubic foot or

$$0.132 \times 1728 = 228.096$$

cubic inches, taking the stroke as twice the diameter.

$$d = \sqrt[3]{\frac{228.096}{2 \times 0.7854}} = \sqrt[3]{145.025} = 5.24$$

inches diameter of plunger, or 5¼; length of stroke equals,

$$2 \times 5\tfrac{1}{4} = 10\tfrac{1}{2}$$

inches. By having these two dimensions, I cannot find out if I have exceeded the piston speed, which should not exceed 100 feet per minute.

W. N.

1. Wrought iron expands 0.0000067302 of its length for each degree Fahrenheit that it is heated. The temperature of steam of 125 pounds gage (140 pounds absolute) pressure is 352.8 degrees. The extension of length by heating will therefore be

$$325 \times (352.8 - 70) \times 0.0000067302 = 6.64 \textit{ foot, or } 0.64 \times 12 = 7.68$$

inches. There would be additional lengthening by stretching under pressure if the diameter were considerable.

2. The temperature range between — 10 and + 70 is 80 degrees. The pipe would therefore shorten by cooling to — 10 degrees

$$325 \times 80 \times 0.0000067302 \times 12 = 2.1 \textit{ inches.}$$

3. The code of the American Society of Mechanical Engineers requires in round numbers 30 pounds of water to be evaporated per hour per horsepower and stipulates that the boiler must be able to do one-third more than its rating, i.e., to evaporate 40 pounds per hour per horsepower. A pump must be able not only to maintain the feed at the maximum rate of evaporation but to "catch it up," or to raise the water line if it has fallen or if the conditions call for it. In view of this and of the fact that it is not desirable to run the pump continually at its maximum speed, a pump of a displacement equal to twice the water required to maintain the rating should be used, and let the slippage be included in that allowance.

Five hundred boiler horsepower requires $(500 \times 30) \div 60$ pounds of water per minute. Double this and divide by 62, the weight per cubic foot, and find that there are

$$\frac{500 \times 30 \times 2}{60 \times 62} = 8$$

cubic feet (prox.) per minute.

The plunger must be of such area that moving at 100 feet per minute it will displace 8 cubic feet per minute, i.e.,

$$100 \times \textit{area} = 8$$

and

$$\textit{area} = \tfrac{8}{100} \textit{ square foot}$$

or

$$\frac{8 \times 144}{100} = 11.52 \textit{ square inches.}$$

$$\textit{Diameter} = \sqrt{\frac{\textit{area}}{0.7854}} = \sqrt{\frac{11.52}{0.7854}} = \sqrt{14.667} = 3.83 \textit{ inches,}$$

to which you would use the nearest or next larger commercial size.

Hight of Water Tank

I have a tank 70 feet above the main where the pressure is 40 pounds. How much will I have to raise the tank to get a pressure of 65 pounds in the main?

W. O. R.

If an elevation of 70 feet gives a pressure of 40 pounds, it would take a hight of 114 feet to give a pressure of 65 feet. But there is something wrong either with the measurement or with the pressure gage; 70 feet from the top of the water to the gage would give a pressure of 30.3 pounds per square inch, and to get a pressure of 65 pounds would require a hight of 150 feet.

Locating Vacuum Line

In an indicater diagram, why is the vacuum line at sea level drawn below the atmospheric line at a distance equal to 14.7 divided by scale of spring?

W. W. D.

The pressure of the atmosphere at sea level is 14.7 pounds per square inch and the vacuum line on an indicator diagram is drawn at a distance below the atmospheric line which will in the scale of the spring (which was used when the diagram was taken) represent a pressure 14.7 pounds below that of the atmosphere.

This distance in inches or fractions of an inch is found by dividing 14.7 by the scale of the spring. By the scale of the spring is meant that a pressure per square inch corresponding to the scale will move the pencil vertically one inch.

Suppose the scale of the spring which was used in taking a diagram to be 15, then dividing 14.7 by 15 the result would be 0.98 inch, which means that the line of zero pressure would be drawn 0.98 inch below the atmospheric line. If the scale of the spring used was 10, the zero line would be 1.47 inch below the atmospheric line.

Patent Situation on Sirocco Fans in England

An important comment upon the patent situation appears in the decision of the comptroller general of the English patent office dated November 22, 1909, on the application of the Electric and Ordnance Accessories Company, Ltd., makers of the so-called Ordnance fan in Great Britain for a patent on an alleged improved type of blade for the Ordnance fan. In the argument leading to his decision, the following words are used:

"It is clear that Davidson's fan, as far as the official search has gone, stands alone and constituted a great practical advance and for all practical purposes it would appear to be the first fan of the multiblade type in which comparatively long and narrow blades are used.

"Any one conversant with the workings of such machines would understand the specification as applying and applying only to the Davidson type.

"The illustrations given in the drawings of both specifications represent in my opinion Davidson's fan and no other.

"It is clear, therefore, to my mind that the applicant has taken Davidson's fan and made what he declares to be improvements on the blades; but the whole foundation or substratum of his invention is Davidson's mechanism. This may be disguised, but is, in my opinion, the real effect of a proper construction of both specifications read together."

Wherever the phrase Davidson fan is used above is meant the Sirocco fan as manufactured by Davidson & Co., Ltd., Belfast. The decision of the comptroller general on the above application was that a patent was granted for the improved form of blades, but only after the applicant had inserted in said patent their admission of the priority of Davidson's patents which in effect means that Mr. Davidson's consent is requisite to the use of their patent. It is interesting to note that the above decision of the English patent office follows within a month the decision of Judge Hough in this country on the demurrer in the American Blower Company's action against the B. F. Sturtevant Company now pending.

Evening Classes for Wage Workers

Announcement was recently made of an important extension of the work of Columbia University, which will begin in September next. The new undertaking is an outgrowth of the success of the summer session of the university, which has been established for ten years, and which in 1909 attracted 2000 students from all parts of the United States. It is now proposed to extend the operation of the principles which have been so successful in the case of the summer session, so as to provide classes and laboratory work in the evening at the university, and both in the evening and during the day in other parts of New York City, as well as in northern New Jersey and Westchester county, for the benefit of those who are not able to avail themselves of the regular courses of instruction at the university. In particular, evening classes will be organized where wage workers, as well as those who are engaged, professionally or otherwise, during the day, may obtain the best instruction which the university can offer.

The field to be covered by this extension teaching will be very broad. There will be classes organized in languages, literature, history, economics and politics; in various scientific subjects, including electrical and mechanical engineering; in architecture, including drafting and design; in music and fine arts; in preventive medicine and sanitary science; in manual training and the household arts; in teaching; and in law.

For this work a large staff of professors and lecturers will be appointed, chosen in part from the present teaching staff of the university and in part from others with special fitness for work of this kind. The whole undertaking will be under the supervision of Prof. James Chidester Egbert, who, as director of the summer session, has brought that branch of the university's activity to a high degree of excellence. Professor Egbert will also serve as director of extension teaching.

A defective tube in one of the Sterling boilers at the plant of the Congress hotel, Chicago, gave way Thursday, February 10, killing James Gavin and scalding H. Struckland so severely that he died on Monday, February 14, at St. Luke's hospital.

At San Diego, Cal., on February 14, the explosion of a steam pipe on the torpedo boat destroyer "Hopkins" resulted in the fatal injury of two men and the severe scalding of five others. The two men fatally hurt could have escaped uninjured, but they turned back and inhaled steam in an effort to save their shipmates.

PERSONAL

A new city position, that of consulting engineer for the department of public works, of Chicago, was created and filled February 15, by the appointment of Henry A. Allen, senior member of the engineering firm of Henry A. Allen & Co., First National Bank building.

At the same time John J. Hanberg, commissioner of public works, named George F. Samuel, an assistant engineer, as acting city engineer, to take the place of John Ericson who is now on a ninety-day leave of absence on account of his indictment in connection with city-hall deals.

Mr. Allen was one of the engineers named by President Taft to decide whether the Panama canal should be of a lock or sea-level type, and at that time accompanied President Taft, then secretary of war, to the Isthmus. He graduated as an engineer from the United States naval academy in 1887 and for eleven years was with the Allis-Chalmers Company. He designed the three big engines at the Chicago avenue pumping station and has made many tests for the city and sanitary district.

Mr. Samuel is a graduate of the University of Michigan. Since 1898 he has been in the city service, connected at different times with every division of the engineering bureau, and is now in charge of pumping stations, cribs and tunnels.

Mr. Allen will have supervision of the bureau, while Mr. Samuel will attend to the details, and together they will immediately start working out a scheme of uniform specifications for the engineering department of the city.

SOCIETY NOTES

The Pennsylvania State convention of the N. A. S. E. will be held in Scranton, June 3 and 4 next, President Foster, of the International Correspondence School, has given one of the floors in the main building to the association, so that there will be ample space for the convention and exhibition purposes.

On Tuesday evening, February 15, A. R. Maujer gave an interesting talk to members and guests of the Modern Science Club, of Brooklyn, on the "Theory, Design and Construction of Chimneys." Mr. Maujer's long experience as chief engineer of the M. W. Kellogg Company, chimney builders, aided in fitting him to present the subject in a pleasing and instructive manner. Lantern slides were used freely, illustrating the salient features, both desirable and undesirable, in the design and construction of steel, common- and radial-brick, stone and concrete chimneys. A lively discussion followed the discourse.

"Tests of Two Types of Tile-roof Furnaces under a Water-tube Boiler," by J. M. Snodgrass, has just been issued by the engineering experiment station of the University of Illinois as Bulletin No. 34. It consists of a report of eight boiler tests made upon a 210-horsepower water-tube boiler of the Heine type set over a chain-grate stoker. In the first four tests the tubes of the lower row of the boiler were completely surrounded by the tile which formed the roof of the furnace; in the last four tests the roof tile rested upon the tubes of the lower row, leaving the lower half of the tubes directly exposed to the flames and hot gases arising from the fire bed. The last four tests show a slightly higher efficiency, more uniform fire control and a

lower temperature in the furnace, combustion chamber and stack, than were obtained when the tubes were entirely covered. In the matter of smokelessness, the covered tubes are shown to be superior. Copies of Bulletin No. 34 may be obtained gratis upon application to W. F. M. Goss, director the engineering experiment station, University of Illinois, Urbana, Illinois.

NEW INVENTIONS

Printed copies of patents are furnished by the Patent Office at 5c. each. Address the Commissioner of Patents, Washington, D. C.

STEAM, WATER AND GAS PRIME MOVERS

WAVE MOTOR. Carl O. Blauel, Düsseldorf, Obercassel, Germany. 947,321.

STEAM TURBINE. William E. Seelye, Cœur d'Alene, Idaho. 947,355.

ROTARY ENGINE. Joseph Jagersberger and Anton Zemann, New York, N. Y. 947,430.

ROTARY EXPLOSION ENGINE. Enrique J. Conill, Paris, France. 947,480.

EXPLOSIVE ENGINE. Howard H. Wixon, Chicago, Ill. 947,566.

INTERNAL-COMBUSTION ENGINE. Francis W. Brady, Englewood, N. J. 947,633.

CURRENT MOTOR. Alden R. Brewer, Plainview, Texas. 947,672.

ELECTRICAL APPLIANCES

STORAGE BATTERY. Walter M. Jackson, Stamford, Conn., assignor of three-fourths to Walton Ferguson, New York, N. Y. Joel M. Anderson, administrator of said Jackson, deceased. 947,238.

RECORDING ELECTRICAL METER. Maurice J. Wohl, New York, and Harry Hertzberg, Brooklyn, N. Y., assignors to Abbott A. Low, Horseshoe, N. Y. Maurice J. Wohl, New York, and Harry Hertzberg, Brooklyn, N. Y., trustees. 947,266.

ELECTRICAL MEASURING INSTRUMENT. Maurice J. Wohl, New York, and Harry Hertzberg, Brooklyn, N. Y., assignors to Abbot A. Low, Horseshoe, N. Y. Maurice J. Wohl, New York, N. Y., and Harry Hertzberg, Brooklyn, N. Y., trustees. 947,267.

ELECTRIC GENERATING MACHINE. Ervin M. Fitz, Columbus, Ohio. 947,279.

CONTROL SYSTEM FOR ELECTRIC MOTORS. Max Hartenheim, Hale, England, assignor to Westinghouse Electric and Manufacturing Co., a Corporation of Pennsylvania. 947,329.

ELECTRIC CIRCUIT CONTROLLER. Henry D. James, Pittsburg, Penn., assignor by mesne assignments to Westinghouse Electric and Manufacturing Company, East Pittsburg, Penn., a Corporation of Pennsylvania. 947,336.

MOTOR-CONTROL SYSTEM. Francis H. Shepard, Pittsburg, Penn., assignor to Westinghouse Electric and Manufacturing Company, a Corporation of Pennsylvania. 947,313.

INDUCTION GENERATOR FOR IGNITION PURPOSES. Henry J. Podlesak, Chicago, Ill., and Tesla E. Podlesak, Morristown, N. J. 947,647.

DYNAMO-ELECTRIC MACHINE. Benjamin G. Lamme, Pittsburg, Penn., assignor to Westinghouse Electric and Manufacturing Company, a Corporation of Pennsylvania. 947,389.

MAGNETIC CLUTCH. Henry W. Ravenshaw, Hanwell, England. 947,687.

DYNAMO-ELECTRIC MACHINE. Egbert M. Tingley, Pittsburg, Penn., assignor to Westinghouse Electric and Manufacturing Company, a Corporation of Pennsylvania. 945,425.

BATTERY-ELECTRODE SUPPORT. Chas. B. Schoenmehl and Wilfred Straw, Waterbury, Conn.; said Straw assignor to said Schoenmehl. 945,614.

RESISTANCE-GRID. Herbert W. Cheney, Milwaukee, Wis., assignor to Allis-Chalmers Company, a Corporation of New Jersey. 945,082.

DYNAMO-ELECTRIC MACHINE. Ray Flagg, St. Louis, Mo., assignor to Wagner Electric Manufacturing Company, St. Louis, Mo., a Corporation of Missouri. 946,212.

ELECTROMAGNETIC DEVICE. Harry G. Geissinger, New York, N. Y., assignor to Geissinger Regulator Company, of New York, N. Y., a Corporation of New York. 946,215.

SWITCH CONSTRUCTION. William M. Scott, Philadelphia, Penn., assignor to the Cutter Electrical and Manufacturing Company, a Corporation of New Jersey. 946,157.

ELECTRICAL-FUSE BLOCK. Andrew A. Moffitt and George E. Andrews, Providence, R. I. 946,251.

PINLESS SWITCH. Heenan S. Goughnour, Johnstown, Penn., assignor to the Lorain Steel Company, a Corporation of Pennsylvania. 946,349.

ALTERNATING-CURRENT MOTOR. Valere A. Flynn, London, England. 946,502.

SINGLE-PHASE COMMUTATOR-MOTOR. Vakere A. Flynn, London, England. 946,503.

ALTERNATING-CURRENT MOTOR AND GENERATOR. Valere A. Flynn, London, England. 946,504.

ALTERNATING-CURRENT MOTOR. Valere A. Flynn, London, England. 946,505.

ELECTRIC LAUNDRY-IRON. Earl H. Richardson, Ontario, Cal., assignor to Pacific Electric Heating Company, Ontario, Cal., a Corporation. 946,070.

ELECTRODE FOR VAPOR ELECTRIC APPARATUS. Percy H. Thomas, East Orange, N. J., assignor to Cooper Hewitt Electric Company, New York, N. Y., a Corporation of New York. 946,079.

LIGHTNING ARRESTER. Percy H. Thomas, Montclair, N. J., assignor to Cooper Hewitt Electric Company, New York, N. Y., a Corporation of New York. 946,080.

DYNAMO ELECTRIC MACHINE. John W. Burleigh, Taunton, England, assignor to Zone Dynamo and Motor Patents Company, Ltd., London, England, a Corporation of Great Britain. 946,105.

PUSH-BUTTON-SWITCH RECEPTACLE. Norman Marshall, West Newton, Mass., assignor to the Arrow Electric Company, Hartford, Conn., a Corporation of Connecticut. 945,969.

RESISTANCE UNIT. Elihu Thomson, Swampscott, Mass., assignor to General Electric Company, a Corporation of New York. 945,993.

CONNECTOR FOR ELECTRIC CONDUCTORS. Harry G. Weeks, Pittsfield, Mass., assignor to General Electric Company, a Corporation of New York. 945,995.

SYSTEM OF ELECTRICAL DISTRIBUTION. Albert S. Hubbard, Belleville, N. J., assignor to Gould Storage Battery Company, a Corporation of New York. 946,045.

MISCELLANEOUS TOOLS AND APPLIANCES

CARBURETING APPARATUS. Frederick B. Hill and J. W. Westwood, London, England. 947,639.

GASKET FOR HOSE COUPLINGS. Robert S. MacEwan, Troy, N. Y. 947,645.

VALVE STEM OR ROD. Christ Kiess, Selbert, W. Va. 947,593.

WRENCH. Asa A. Orr, Belle Vernon, Penn. 947,619.

STARTING AND STOPPING DEVICE FOR GAS AND OTHER ENGINES. Thomas W. Ellis, Denison, Texas. 947,437.

LUBRICATING MECHANISM. William L. Morris, Batavia, Ill. 947,449.

VALVE. Theodore R. Sundberg, Salt Lake City, Utah, assignor of one-half to Louis S. Cates, Bingham Cañon, Utah. 947,463.

LUBRICATING BEARINGS. Charles R. Meston, St. Louis, Mo., assignor to Emerson Electric Manufacturing Company, St. Louis, Mo., a Corporation of Missouri. 947,529.

CONNECTING-ROD COUPLING. Joseph W. Bready, Westfield, Mass., assignor of one-half to Clarence W. Jacobus, Springfield, Mass. 947,567.

LUBRICATOR. Pericils Chilimidos, Philadelphia, Penn. 947,568.

PIPE COUPLING. Joseph E. Costa, Downey, Cal. 947,711.

CARBURETER. Garrett W. Hendricks, Indianapolis, Ind., assignor by direct and mesne assignments to Improved Carbureter Co., a Corporation of Indiana. 947,712.

APPARATUS FOR THE PRODUCTION OF CARBURETED AIR. Mortimer F. Mieville, Chichester, England. 947,717.

WRENCH (PIPE). Herman A. Paquette, Chicago, Ill., assignor to the Richards Manufacturing Company, Aurora, Ill., a Corporation of Illinois. 947,346.

SEPARATOR. Josef Muchka, Vienna, Austria-Hungary. 947,393.

JACK FOR STARTING ENGINES. William C. Byington, Bogalusa, La. 947,294.

CRUDE-OIL BURNER. John B. Brennan, Sherman, Texas. 947,293.

OIL BURNER. Glenn D. Will, Eureka, Cal. 947,363.

MANUFACTURE OF FUEL. Thomas Parker, Wednesfield, England. 947,400.

ENGINEERING SOCIETIES

AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Pres., George Westinghouse; sec., Calvin W. Rice, Engineering building, 29 West 39th St., New York. Monthly meetings in New York City. Spring meeting at Atlantic City, May 31 to June 6.

NATIONAL ELECTRIC LIGHT ASSOCIATION

Pres., Frank W. Frueauff, Denver, Colo.; sec. and treas., Frank M. Tait. Association York. Next annual convention, St. Louis, Mo., May 23-28.

AMERICAN SOCIETY OF NAVAL ENGINEERS

Pres., Engineer-in-Chief Hutch I. Cone, U. S. N.; sec. and treas., Lieutenant Henry C. Dinger, U. S. N., Bureau of Steam Engineering, Navy Department, Washington, D. C.

AMERICAN BOILER MANUFACTURERS' ASSOCIATION

Pres., E. D. Meier, 11 Broadway, New York; sec., J. D. Farasey, cor. 37th St. and Erie Railway, Cleveland, O.

WESTERN SOCIETY OF ENGINEERS

Pres., J. W. Alvord; sec., J. H. Warder, 1735 Monadnock Block, Chicago, Ill.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA

Pres., E. K. Morse; sec., E. K. Hiles, 803 Fulton building, Pittsburg, Penn. Meetings 1st and 3d Tuesdays.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Pres., L. B. Stillwell; sec., Ralph W. Pope, 33 W. Thirty-ninth St., New York. Meetings monthly, excepting July and August.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.

Pres., William G. Snow; sec., William M. Mackay, P. O. Box 1818, New York City.

UNIVERSAL CRAFTSMEN COUNCIL OF ENGINEERS

Grand Worthy Chief, W. S. Cadwell, Chicago, Ill.; sec., Thomas H. Jones, 244 Eighth street, N. E., Washington, D. C. Next convention, Buffalo, N. Y., August, 1910.

NATIONAL ASSOCIATION OF STATIONARY ENGINEERS

Pres., William J. Reynolds, Hoboken, N. J.; sec., F. W. Raven, 525 Manhattan building, Chicago, Ill. Next convention, Rochester, N. Y., September, 1910.

AMERICAN ORDER OF STEAM ENGINEERS

Supr. Chief Engr., Frederick Markoe, Philadelphia, Pa.; Supr. Cor. Engr., William S. Wetzler, 753 N. Forty-fourth St., Philadelphia, Pa. Next convention, Philadelphia, Pa., June, 1910.

OHIO SOCIETY OF MECHANICAL, ELECTRICAL AND STEAM ENGINEERS

Pres., O. F. Rabbe; sec. and treas., Prof. F. E. Sanborn, Ohio State University, Columbus, Ohio.

INTERNATIONAL MASTER BOILER MAKERS' ASSOCIATION

Pres., A. E. Brown; sec., Harry D. Vaught, 95 Liberty street, New York. Next meeting at Niagara Falls, Canada, May 24-27, 1910.

INTERNATIONAL UNION OF STEAM ENGINEERS

Pres., Matt. Comerford; sec., Robert A. McKee, Peoria, Ill. Next convention, Denver, Colo. September, 1910.

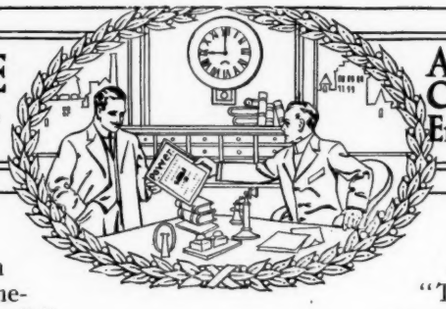
NATIONAL DISTRICT HEATING ASSOCIATION.

Pres., A. C. Rogers, Toledo, O.; sec. and treas., D. L. Gaskill, Greenville, O. Next annual meeting at Toledo, O., May, 1910.

NATIONAL MARINE ENGINEERS BENEFICIAL ASSOCIATIONS.

Pres., William F. Yates, New York, N. Y.; sec., George A. Grubb, 1040 Dakin street, Chicago, Ill. Next meeting, St. Louis, Mo., January 16-21, 1911.

MOMENTS WITH THE Advertising Editor



A Department for Subscribers Conducted by the Business End of Power and the Engineer

I'm beginning to think," said the Fireman, as he knocked the ashes from his pipe, "that there must be something in this advertising game after all."

"You're *beginning* to think so," said the Engineer, tipping back in his chair and gazing intently at a spot on the ceiling. "And just when and how, may I ask, did this brilliant idea force itself through a two-inch thickness of bone and find lodgement in that part of your anatomy technically known to the medical profession as your cerebellum?"

"Well, you needn't get sarcastic about it," replied the Fireman. "There's nothing the matter with my think-box. Going home on the car last night a crowd from the Boiler Works got on. The Chief was there, reading POWER AND THE ENGINEER, and I noticed that he was reading the advertising pages. Pretty soon he took out his memorandum book and made a few notes in it. Then he took out his knife and cut out one of the ads. And when I left the car he was still reading. What he says *goes* up at the Works, and I bet that somebody gets an order."

"Say, you're a regular Sherlock Holmes, you are," answered the Engineer. "You'll be calling me 'my dear Watson' pretty soon. The first thing you know you'll be coming down to work with a punctured eyeball acquired by colliding with a hat pin thrust through a key hole at the psychological moment. Your powers of observation are nothing short of marvelous—*marvelous;* but like charity they should begin at home. The trouble with you is that you're all eyes *outside* this plant, but inside you can't see beyond the length of your stoker bar. If you could, you would have seen that the Chief at the Boiler Works wasn't the only one that reads advertisements. Not by a long sight! Inside this plant your powers of perception are warped, stunted. And as for your bump of curiosity, it's conspicuous by its absence. If you possessed a normal sense of curiosity you would have found out long before this what I do with that big scrap book I keep behind my desk, even if you had to swipe it when I was out at lunch. Your education has been sadly neglected along certain lines; you're half baked, but I see that you possess 'the germ,' and as a kindness it's up to me to develop it. So I'm going to turn the sunlight on it in hopes that I can induce it to wiggle a little.

"I keep *advertisements* in that scrap book.

"The gilded youths of Wall Street hang over the ticker, a cigarette in one hand and a bottle of Paris Green in the other, ready for any emergency. By means of the tape they can follow the market.

"Now I'm not a speculator. I'm an *investor*. And by reading the advertising pages of POWER AND THE ENGINEER I can follow the market too—the only market that interests me. Whenever I come across something that looks good, something new, I cut it out and paste it in my book. I've got the book classified. If I see a good Water Alarm, I put it under A. If a certain kind of a Blower interests me, it goes in under B. And so on, right down to Wrenches. It doesn't make any difference whether I need the article immediately—if it appeals to me in any way I paste it in. Then, you see, I've got an up-to-date record of the things I am likely to need, and when I *do* need them, I turn to my book and see what's doing. And I'm not the only one who is keeping a book like this, either."

"Does it pay?" asked the Fireman.

"Does Clarence squeeze Maud's hand at the show!" replied the Engineer. "Look around you. Look at those unions on that pipe line—look at that oil filter—look at that new engine—look at that stoking device—cast your optics on that feed-water regulator and that indicator. Then ask me, 'Does it pay?' if you dare.

"Every one of 'em were purchased because I read my advertisements. And all of 'em are saving money and standing me in well with the Old Man. Couldn't do it some years back, though, when an indicator ad consisted of two words—GOOD INDICATORS, and a boiler ad of two words—GOOD BOILERS. Ads used to contain about as much live information as a laundry mark on a collar. And were just about as interesting. Some of 'em were like Chink laundry tickets, the only one they ever meant anything to being the man who wrote 'em. Nowadays advertisements are read for the sake of what's *in them*. When a concern has anything to say it comes right out and gives you the whole story, instead of making you strain your imagination trying to read between the letters of their name. After I get through with this week's issue of POWER AND THE ENGINEER you take it and read it, starting from the back cover and working forward. Then come and tell me what you think of it."

"Still, I've heard of some people tearing out the advertising pages and throwing them away," said the Fireman.

"H—l!" said the Engineer, "Some people peel bananas and throw away the inside."